THE

ARCHITECT'S GUIDE

BEING

A TEXT BOOK OF USEFUL INFORMATION

FOR

ARCHITECTS, ENGINEERS, SURVEYORS, CONTRACTORS
CLERKS OF WORKS,

ETC. ETC.

BY FREDERICK ROGERS, ARCHITECT

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ETC. ETC.

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PREFACE.

THIS little work contains the most valuable of the materials and tables before published in the "Architect's Guide" and the "Architect's Text Book," revised and corrected to the present time, with the addition of a large quantity of original matter.

Great pains have been taken to collect information which may be required, or which will be found useful, either in the office or on the building, with the object of forming what, it is confidently believed, will prove a valuable book of reference to all who are engaged in the art and science of building.

As an appropriate introduction to the volume, especially in the hands of the architectural student, Mr. Billings' valuable paper, "On the Profession of an Architect," has been retained.

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ON THE PROFESSION OF AN ARCHITECT.

BY R. W. BILLINGS,

AUTHOR OF "ILLUSTRATIONS OF CARLISLE AND DURHAM CATHEDRALS," "THE ANTIQUITIES OF SCOTLAND," AND OTHER WORKS.

A VERY earnest writer, alluding to various topics connected with his own art, and with the sister art of civil engineering, strongly urges the combined study of beauty in form, and the correct application of material, as an essential principle in the formation of an architect; the simple fact being that an ugly, ill-contrived edifice is just as costly as one which is well arranged and beautifully designed. The bad and good pictures, as represented figuratively by buildings, are, unlike all other things in the world, paid for by equal prices, and thus quality and mere quantity are most absurdly made equal, both being brought to a dead level of reward,—a position as unjust as the modern system of reducing all men's wages to an equal rate, no matter how inferior the quantity and quality of one man's work be to another. Thus, the carpenter who is physically endowed by nature with strength to produce more results than his weaker brother, is compelled, by an equal rate of payment, to work down to the level of the weaker
65 vessel; and all seems to be resolving into an undesirable level of mediocrity, where the weaker regulates the

stronger, whether in mind or in matter. Coming back, however, to the subject of good designs and bad, our comparison is hardly extensive enough; for the ugly in architecture is generally the most expensive. As the writer before referred to justly remarks on material, true merit is the "wisdom of putting it together."

In entering upon the profession of an architect, it will be well that the young man should (in building terms) carefully weigh the cost of *time and material* necessary to be expended, before he can fairly enter upon the practice of the profession; and above all things, he should satisfy himself that, in entering upon the study of the art, he is in love with it, and especially that no passing fancy or mercenary views of future fortune have been the real objects of his choice; for if this be the case, he will, in all probability, be most woefully disappointed; and, moreover, most justly so, for any art pursued for the mere greed of gain must end, as money-making matches generally do, in indifference, if not distaste and separation.

He should carefully consider whether the undue preponderation of circumstances against ultimate success (i.e. independent employment, and the profits and honours of the profession) will affect his case. And it will be well for him to know that the architect cannot paint his own pictures—cannot produce the result of his study, as to erecting buildings, unless he is employed; that, as a consequence, the profits of the profession carry away the honours in company, and that, instead of a competition of designs, proved to be executed by men's own hands, being the source of academic distinction, the fashionable architect may possibly obtain the prize by the work of others.

Nor should it ever be permitted by the parents or controllers of any youth to enter upon the calling of

architecture, unless he have preponderating talent for the profession and its numberless requirements; and, above all, unless the young man have expectations, or in plain words, powerful connections to give him business, or to recommend his employment to others.

It may be taken for granted that these conditions exist in full force; and, whatever his ability may be, the chances are that the profession, as an independent one, is closed to him, after all his years of study, and all the cost thereof; that his principal chance will be that of taking a situation as a clerk, for some years, upon a less salary than the wages obtained by the ordinary bricklayer or carpenter. His parents or friends will, in the majority of cases, be able to rejoice in knowing that the salary he will receive is not the common interest of the money laid out upon the production, or rather the education, of the living building material, called an architect.

True it is, that cases occasionally crop out where a young architect without business connection does establish himself in the profession, by the aid of that raffle for a living known as competition designs; but such instances of drawing the winning numbers do not in any way indicate a principle, but are exceptions,—mere chances.

So great, in fact, are the difficulties of the young architect in finding practical and independent action after his long years of apprenticeship, that it is questionable if one-third of the number educated remain in the profession, the bulk being ultimately absorbed into the commercial world, which might have been entered upon without one tithe of the cost either of time or money.

The architect is supposed to be an artist; but nothing can be more difficult than defining whether architecture is an art at present—whether a profession or a trade, and whether its professor is an artist or a mechanic and

tradesman. Architecture is always defined as the elder sister of the arts of painting and sculpture; but can any greater contradiction be given to the art question than the fact of the profession descending from the wealthy father to the fortunate son by the mere operation of mechanical official education, and too often by the employment of other ability than their own?

Looking to painting, sculpture, or engraving, or taking the highest flight of poetic imagination, where do we find the son succeeding the father as the great artist, except in rare instances? If the son has great talents of his own, they constitute a standing claim, and that undoubtedly sheds an additional lustre on his predecessor's fame.

Where is the artistic profession, excepting architecture, in which it is considered otherwise than dishonourable to appropriate the talents of others, or where the practice is not followed by expulsion from the society of bodies of artists? And this notably from the highest academic body in Great Britain.

Nothing has been or can be more fatal to architecture as an art than when fashion lays holds of a professor. So great a quantity of material is required, that he becomes of necessity a manufacturer, producing and re-producing his own necessarily limited ideas of form and detail over and over again—copy—copy—copy, until the eye of the intelligent observer becomes offended with the monotony; and the fame which the careful study of a limited number of works might have created for the favourite, is lost in the overworked and overtasked victim of fortune.

It is really no matter of surprise that an overworked artist of any kind, and with any amount of talent, should end either in the monotony of copyism, or in the production of a quantity of vastly inferior works, utterly unworthy of a great reputation. The most powerful designer

has but a limited range of variation, and, when put upon the stretch, it requires length of time and great care for successful development. Undue pressure upon any brain must produce both monotony and mediocrity. Undoubted proof of this may be seen in the works of the greatest architect England ever saw; and the City of London is full of the highest flights of genius and the depths of puerility from the same hand, by having been intensely overworked. The most ordinary observer may see this by noticing the poverty-stricken exteriors and equally artistic interiors of the same buildings; and most notably the Church of St. Stephen's, Walbrook.

Nor is this the end of the mischief committed by the famous or fashionable architect. He is not only the cause, by monotony in himself, of retarding the progress of design, but, in his greed of monopoly, he is the suppressor of the ability of other men in every way his equals at the start of the race, but who are unfortunately, from want of employment, utterly precluded from the future running.

If the architect is to be considered an artist, he should be compelled to carry out his designs literally, not only to the extent of the entire working drawings, but to the execution and active personal superintendence of the most minute details; and he should never be permitted to carry out more than one important building at the same time. At last there is the symptom of coming change,* and it is a great step in the right direction that this principle of action has been at last resolved upon in the case of the New Law Courts in London; the true architect will everywhere hail this course as a good omen for the profession, in that it will be a complete test of individual talent, all-sufficient for his wants for the time, leaving the great field of employment open to others, who

* This was written before the competition for this work.—ED.

may have their opportunities for becoming distinguished, and, perhaps, of marching beyond their fortunate compeer.

The writer quoted in our first page also refers to the civil engineer as superseding the architect. Not only has the civil engineer made vast inroads into the practice of architecture, thereby to a certain extent superseding the professor of that art, but there is another cause for the non-employment of the architect, in the fact that many builders employ architects' or drawing clerks, who become thoroughly acquainted with practical matters from being constantly amongst active work of all kinds.

This practice results in the builder occupying the double post of architect and contractor, whereby practically the experience and profits of both *trades* (?) or professions become merged in one individual or firm. And we have in our own time seen this principle adopted and approved by the example of the very highest authority in the kingdom. And not only has the sanction of high position been awarded to the employment of the builder in the capacity of architect, but the same distinction has been conferred on the civil, or rather the royal engineer. The late Captain Fowke will occur at once to the recollection of the reader, as a successful applier of architectural knowledge under the latter-named class. It must also be remembered that a body of highly educated men, such as the Royal Engineers of Great Britain, form no questionable rivals to civil architects, for architecture is now one of their especial studies, and in their own school.

It is to be hoped that, in all cases where the civilian is superseded, practical convenience will atone for the possible lack of artistic combinations, and that the utility question will compensate for the absence of the beautiful, the first being often preferred to the last.

Enormous house-building speculations have, doubtless, had their influence in adding the architect's office to the builder's counting-house. And taking this view of the subject, the inroad of the practical element would seem to be fair, for it would be absurd to suppose that they would depute any part of their risk to the profit of a profession, whose mechanical rules, so far as they are concerned, can be mastered by every workman, and whose practical application the builder generally understands fully better than the architect.

But it very often occurs that the sons of builders are actually educated as architects, and frequently, in entering upon their own business, carry with them the knowledge necessary for all ordinary practical conduct, both in designing and executing any edifice they may have the chance of obtaining. And this practice must be held to be perfectly legitimate, for in this country of free trade all is open to the most enterprising, and the business of the architect, as now conducted, is no exception to the general laws of perfect liberty of action.

There is yet another and more fatal obstacle to the advancement of the architect in the field of design than either the engineer, civil or royal, or even the much-dreaded builder; and that is, the banded associations of amateurs, whether they be called ecclesiologists or otherwise, who sit in judgment upon architects' designs, and demand precedent upon every point before granting their august sanction to the works of those professional men who are weak enough to submit to such necessarily imperfect and arrogant dictation.

According to this last class of enemies to architectural progression, no change is to be permitted, nor is anything to be done without it has been done before in ancient times; and woe to the unfortunate wight who dares travel from the beaten track of mere copyism, if he or his designs have to pass through their hands.

Of all the arts and all the occupations requiring long and careful study to produce tolerable excellence, architecture is one which admits with easy facility of that certain amount of knowledge which may be summed up by the term of specious smattering; yet to the plausible and glib though inane discourser upon dates and styles (especially if he be rich in worldly goods and have power) is accorded the judgment upon the art and its professors, such as would not for an instant be submitted to by any other profession.

Has this interference of amateurs been more the cause of non-advance than all other causes combined? We think the answer must be an affirmative.

Nor must another class of amateurs be left out of the catalogue of modern innovators upon the architect's province. We mean those whose position and fortune enable them to study the profession at leisure, and who in their own persons practise it so successfully as not only to become formidable rivals to the regular professor, but by their own example offer the strongest encouragement for others to follow their footsteps in becoming independent of interference in their art. And looking to the success of such men as the late Earl de Grey, and the late Lord Sudeley, we cannot but admit their claim to a high place in the ranks of architectural oppositionists. The former was an artist by study, and an architect as well, who thoroughly understood the profession. In the first position, he gained honour at the Society of Arts; and in the latter, became so distinguished as to fill the place of President of the Institute of British Architects from its formation until his death. Nor was the latter, better known in his earlier career as Charles Hanbury Tracey, at all behind in the entire knowledge of the profession, as he proved by the design and construction of his own mansion at Toddington, a building at once a

monument of his skill as a practical architect and his taste as an artist. But were architect amateurs all so accomplished as in the instances adduced, the professional architect would have little cause to regret. On the contrary, their intimate knowledge of the art made them an acquisition wherever they appeared, and, as the lawyers say, "save and except" in the case of their own houses, no men in their time ever gave more generous assistance and encouragement to artists of all kinds. Full well they knew the difficulties of their actual professional brethren, and as such sympathized with them, and aided in their employment.

From this we draw the conclusion that the knowledge of such amateurs is honourable to their caste, and their advance no detriment to the working architect. It must be well remembered by many besides the writer, how keenly Lord de Grey advocated that architecture was or ought to be an art, and that all were at liberty to enter its ranks if they possessed the ability and knowledge to do so, as a question of free trade, entirely independent of having passed perhaps the best years of life in learning the mere routine of an architect's office, however eminent that office may be. Both these gentlemen were, in fact, architects; and, but for the accidents of rank and fortune, would undoubtedly have left their mason's marks strongly behind on the pedestal of fame.

Various other classes of enemies hover round the camp of the architectural army, snatching the spoils which formerly fell to their share; and who shall say that they are not fairly entitled to the palm of victory if they have the ability to obtain it? Look for a moment at the decorator internally and the landscape gardener externally, and consider the inroads they have made upon the regular architect. Let those who doubt the fact stated simply recall the career of Sir Joseph Paxton, as belonging to the

latter capacity, and of emerging from it, or rather mixing with it the practice of the regular architect. We might add the sculptor and many others to the list, including the land surveyor, the auctioneer, and even the south of Thames local ironmonger, who advertises to design and construct iron churches and chapels in the "first style of Gothic architecture," though what that means, none can tell.

What moral do these inroads teach the architect, if they do not tell him that he must make himself the master of all the arts opposed to him, and, by the superiority of his combined artistic and practical knowledge, outstrip all others, and so lead in the race? He must look up to and worship freedom of thought and of action, and endeavour to remove from his profession the stigma of being the only one which in modern times has made no great artistic discovery, nor any real advance by the hands of its professors.

If the whole body of architects will be exclusive in their modes of conduct, if they will clothe themselves with the mantle of precedent, or be content with relying upon the applications of the repetition of past productions of their art, or business, and just what any mechanical labour can supply, it is obvious that their occupation will pass away into other hands; for it is perfectly impossible that, with the new materials at hand, and the enormous facilities now afforded for general education, that one art can stand still while all others are rapidly marching onward.

It must never be lost sight of by the architect, that his *office* is no longer the sole depository of his art. For instance, and quite independent of numberless recent works on the profession, a general and, if the student so wills it, a very particular knowledge of all that can be given relative to architecture, is now afforded by the Government Schools of Design; and it depends entirely on the pupil whether

he come from those schools with a mastery of all that is necessary for ordinary practice or not. Not only is this obtainable at the most moderate cost, but that most important of the arts connected with architecture, Perspective, is there systematically taught, and, as a consequence, the modern architectural exhibitions bear ample testimony to the extended knowledge of this most important aid to any of the arts, and most especially to architecture.

Wanting the aid of an intimate knowledge of perspective, the architect cannot possibly judge of the effect of his arrangements; and very often what appears perfect in plans, elevations, and sections, becomes painfully deficient when executed, from the want of that knowledge of actual appearance which should enable the designer to know the result of his labours before their execution. It should be required of the architect, and before any building is commenced, to produce rapid sketches from every required point of view, and especially of all important buildings, more particularly of those placed in cities, where the effect of the new production may be made or marred by its mere connection with edifices already erected.

This all-important consideration of perspective has not, until recently, had the care bestowed which it deserves; and the numbers of practising architects who, in the last generation, were masters of the art, could be counted on the fingers. There was one who did thoroughly understand it, who did enjoy its practice as an artist should do, and that one was the late Professor Cockerell. He agreed with the writer of these lines that the intimate knowledge of this art was one of the great rounds which led up the ladder of difference between the mechanic and the artist.

Resuming, for a moment, the question of an architect's education and the means of obtaining it. Whether the

student obtain his preliminary knowledge by means of long servitude in an architect's office, or through schools of design, aided by the enormous accumulations of theoretical and practical works on the art, there is an all-important point, in our estimation, never to be neglected. That point is the reversal of the young builder making himself acquainted with the rules of architecture.

We consider it essential that the young architect, for a while, after he has mastered as much theoretical knowledge as is possible, and before he starts in the professional race, should drop the graceful mantle of gentility, which generally shrouds the conduct of the profession, and descend into the arena of actual work; i.e. that he should, for a year, at least, enter a builder's workshops, and learn all the appliances, materials, and modes of working of all kinds. He will then understand workmen better than the race which passed before him, and will know how to consider and use them. He will be able to direct and control them effectively, and they, in turn, will respect the man who is really able to direct. We hold it essential that every man should himself have positive knowledge, and, if need be, the power of executing all matters and works he is called upon to direct. He should, in fact, be in the position of the commanding soldier, who directs the battle, but whose knowledge and power of fighting always stands him well in the event of desperate circumstances.

Again, there is another accomplishment in which an architect should never be deficient, that of modelling and carving all ordinary objects of nature necessary for the decoration of his work; and fortunately the instruction and early practice of this can be readily obtained in the various schools of design. It is always a legitimate extension of his means of employment; and will serve him well at all times and in all places. More especially will it be

of great benefit to him and his designs, that he should, wherever his works may compel him to travel and reside, be able to take the plants and foliage of the locality, as our forefathers did; so that instead of repeating one capital or one bracket hundreds of times over, he should design and roughly model, either for the workman or for his own handiwork, the numberless variety nature offers, and so, by making his works designs belonging to the country, rise to the artist, instead of grubbing along as the mechanical copyist of foreign patterns,—a practice needing little study or talent.

The work of the architect is, for the most part, of a sedentary nature, allowing but scanty opportunity for obtaining physical exercise; and any occupation, such as the vigorous handling of the mallet and chisel in realising his own designs, must be conducive to health and to vigorous thought. Those few professional men who practise the art of carving know fully the value of its acquisition, both as to variation of occupation and absolute profit. They know and feel that the result of their chiselling is what they intended to produce, and not the mutilation of their designs by an inferior hand. That the ancient designers were working architects and real masons there can be no doubt; and, by their combination of thought and action, were, doubtless, as sound in body as in mind. Did they die, as many modern architects do, before their time, from confining themselves to sedentary occupation? We believe not; and we know for certain that they did not despise the dignity of labour. This, to all who look to the gentility of the profession as its highest point.

Especially should the young architect apply himself to the practical working of carpentry, no matter how low he begins on the rounds of the ladder of that useful knowledge, nay, even if he descend to making a common dovetailed box. What a field of useful, nay, of absolutely

required information to the architect, is implied in the acquisition of this art! and what number of months would not be profitably spent in gaining it!

There is not only the beginning of joinery in the shape of the mortise and tenon, but there is the practical application of lines and curves, and of innumerable mechanical appliances used in construction of all kinds, going on to the daily practice of gaining knowledge relative to the qualities of different kinds of timber and other materials entering into the construction of buildings generally. There is wood, and there is wood, but one may be good, and the other may be very rubbish, such stuff as we often see in the condition of having no stamina, through the circumstance of bleeding to death by the extraction of all the turpentine as an article of commerce. The experienced carpenter knows which is which, blindfolded; but then he has seldom the power of acceptance or rejection of material. The case of the architect, however, is totally different, for the power named is one of his especial provinces; and there is no way of gaining the knowledge of material so thoroughly as by being among the workers of the materials, and by working amongst them himself.

The architect, too, must be more or less an engineer, versed in all mechanical laws and powers, as well as in all modes and contrivances connected with constructive art, as surely as he must be with the theory of design in all its various phases. Here the engineer has a marked advantage, because he has no occasion whatever for being an architect, unless it pleases his fancy to become master of the principle of architecture. He may become eminent in his own profession without even any knowledge of the five classic orders, and without being able to discriminate between the styles of our own ancient buildings. Of course it is greatly to the advantage of the

engineer to understand architecture fairly, in that it enables him to graft upon his mechanical or practical works whatever features of the sister art are required in a proper manner. And it will not be for a moment doubted that an advantage so obvious will be allowed to sleep under the hands of the most enterprising and independent profession of the age; a profession which admits frankly into its ranks all who have either the natural or acquired ability necessary for joining their army of workers, but which, fortunately, has no fettering amateur committees or precedent to mar the designs of its professors. Nor, indeed, would the body of civil engineers for one moment admit such interference and repression of their art. The consequence of this independence is that they are becoming artists and architects as well, and there are modern instances arising and completed to prove the assertion. Metal is their feature, as stone is that of the architect, and it is a question whether the graceful curved forms in iron, now spanning the river Thames at Blackfriars, at Westminster, and at Pimlico, have ever been surpassed by those of any bridge in stone. Looking to this fact of rivalry, is it not incumbent on the older profession to unshackle itself from precedent, to derive experience from the facts of the past, and to march boldly in the race of inventive power, ceasing to be guided in leading strings by any fashion, however high, or by any repressors, however influential?

Another step towards the experience actually needed by the young architect, before commencing real practice, is to take the position of Clerk of the Works,—first, upon the alterations and additions requisite to change and make fit an old house for modern requirements, and secondly, to lay out and superintend the erection of more than one building from its commencement to its finish, watching minutely every stage of progress, and laying his

mind to the various contrivances necessary for surmounting peculiar difficulties and requirements as they occur, taking advantage of the long experience of the older workmen, and, in fact, making himself master of all the processes of putting up, as well as of pulling down; for in doing the latter properly and carefully, when making alterations upon old buildings, more art and careful contrivance are required than is generally supposed. Modern building wants are so totally different to ancient, from the drain-pipes of the foundation to the gutters of the summit, and in many cases so far in advance of them, that the two studies become really interesting as mere matters of comparison. Take, for instance, the question of distributing bell wires in an economical and efficient manner, or the distribution of water and of gas through a modern house. The reader will at once understand some of the modern wants. The proper distribution of various pipes through a modern mansion, whether they be for water, air, sound, gas, bells, sewage, or ventilation, involves much practical knowledge, and is of such consequence to modern notions of comfort, that the architect who combines this with his proper profession has little need to fear want of employment. And while a building is being erected, and all parts exposed, every arrangement of this kind ought to be planned, and every opening left for the passage of wires and of pipes of all kinds. The planning of these things properly affords an opportunity in which the architect may be of immense service, both in saving the heavy expense of cutting and boring through walls, and in preventing the damage often done to new buildings, when such boring and cutting become necessary through neglecting these important preliminaries.

In the modern building all is open, and, therefore, appliances of comfort are easily accomplished, if properly

planned; but in the ancient one all is hidden, and difficult in proportion, because the questions of baths and closets, pipes and bells, never entered into the intentions of their designers. But if there is difficulty in planning these additions to existing buildings, much corresponding information is gained in attempting to carry them out, and a vast fund of amusement to those interested arises from the obstructions which continually crop up to test the powers of the man in charge in surmounting all retardations and accidents of the works, of whatever nature they may be: conquering all these, the clerk may become, in the end, as of old, the master of the works.

Another advantage will be gained by the young architect, in completing his experience upon actual building; and that advantage is the very important fact of his gradually and surely gaining the actual knowledge which will enable him to occupy the builder's place, and to have a trade, either in the event of his profession failing to be remunerative, or of his failing to find work in it.

Then, supposing an architect has a turn for writing, the literature of the profession requires the laborious occupation of years to master: and so absorbing and extensive has this become in our time, that he who enters upon authorship rarely, if ever, achieves any great fame as an architect. True, the public writer who so wills it has the opportunity of puffing his own wares, and of raving about the production of new effects and new styles; but he has never yet succeeded in performing the feat. Nor is it likely that such an excessive and absorbing occupation should ever afford the opportunity of efficient or active production in any other branch. Whether or no the importance of the literature of architecture be overrated is a question; but if the young architect have great ability either in the artistic or practical branches of the profession, we would advise him to devote himself to

work, and not much to words. One good design well carried out is not only lasting fame, but worth whole volumes of general writing; unless, indeed, they be of such character as the immortal practical productions of a Tredgold, or Nicholson, or Pasley, or works of such enormous labour as the Cyclopædia of Gwilt—he who, to his honour as a true artist, never sought patrons, but requested them to seek him.

The necessity of great care in that part of literature belonging to the profession, i.e. the construction of specifications, has also a share of notice in the paper referred to in our opening page. Deficiency of description and vagueness of meaning in specifications are undoubted and very grave errors to be chargeable against any architect, and are the causes of many conflicts in which the lawyer is the only gainer; for loss of money results to contractor and employer, and loss of character to the director and author of the defective agreement.

It is, however, very difficult to be so specific that words and phrases shall not convey a double meaning, however carefully constructed; and much depends on the character and high forbearance on the parts of both architect and contractor in reading them. Specifications, like acts of parliament, should be so carefully prepared that it would seem impossible to evade their clauses and conditions. Yet what so difficult to accomplish, if we are to believe the assertion of the great Daniel O'Connell, that there was no act of parliament existing through which he could not drive a broad-wheeled waggon.

Specifications fairly rendered will, however, always be read aright by men of high principle, such as our leading contractors undoubtedly are. They require conditions and materials to be fairly described, so that a liberal interpretation may be put upon them. More than one contractor has had just cause of complaint that the draw-

ings estimated from, which are the main guides, often contain the mere indications of elaborations which, after being contracted for, may be so amplified as to amount to ruinous loss, without any redress being possible.

The essential element of completed drawings, as explanatory of an agreement, should always be insisted upon by the contractor, and certainly should never be omitted by the architect. Even to the minutest detail they ought to be attended to, especially when intricate mouldings and other elaborate details are intended. No vagueness or uncertainty ought to exist in such matters, and failing such particulars, no contractor ought to sign any agreement founded on stringent general conditions of completing works to the satisfaction of either employer or architect. It is dangerous in the last degree to commence work on unfinished non-detailed plans, with undeveloped sketches of ornamentation; and the ruin of many a man has resulted from either misconception on the one hand, or the desire to amplify detail on the other, and thus obtain both quantity and quality of work never intended by the composer of the original estimate. The workman is entitled to live by his craft, and any act of neglect, however unpremeditated, which involves the builder in loss against which he cannot defend himself, is indeed culpable in either the architect or the employer.

Modern building is too often a race between the employer and contractor, the one looking to gain a cheaper work than is consistent with good and proper quality, the other as naturally endeavouring by all means possible to bring out the results of a close and keen competition, with such degree of profit as could not exist if the performance in building equalled the promised conditions. Cheap work is of all things the dearest, but it is what nine out of ten employers delight in. How often do we find rich men, while exhibiting their houses, boast of having done

it for so much—or rather for so little—forgetting all the while that sharper men than themselves have been at work, and utterly oblivious of the future enormous and never-ending taxation, in the shape of constant repair, as resulting from that rage of the age, bargains, and of quantity minus quality. If buildings of this kind are erected as investments, their *profitable* (?) nature is soon manifest in the shape of rents, which absorb the greater part of the rent produced by their occupation. And then comes the total loss upon such property while under repair; then, repair and doctor them up in any way you will, so as to show a fair surface for awhile, the original disease is there internally, and will come out afresh. We earnestly recommend the employer to cease to expect or execute cheap work, and the architect who values his own reputation and loves his profession as one of high standing, to go and do likewise, even if he remain without patronage. He may get ready money for a time by erecting cheap works, but he will ultimately find that credit will have deserted his name. Therefore we advise the director to avoid such works, and all works where a practical knowledge of building enables him to know that the contractor must lose money if they are fairly carried out, and must do something worse than merely practise tricks of deceptive-looking work if they are not.

Let the architect be sure that he intends his contractor to obtain a living by the work to be executed, and deliberately refuse his sanction to any bargain he knows would, with honourable conduct, end contrary wise. So shall he rank as the builder's friend, and his own name and fame remain real and solid, as the honest worker out and advancer of his noble art, when the cheap and flashy man has gone to the wall.

Regarding the comparison of the civil engineer with the architect in our own time, it must be admitted that the

former has made the most wonderful advances in the way of original treatment of design, in every material, and especially in the use of iron. And this advance has been made while architects were relying on the past, and submitting to copying precedent and bygone authorities, instead of catching the spirit of former art, and from it producing new combinations. Fatal mistake, and utterly destructive to all love for their profession as the elder sister of design! It may be that some will be inclined to doubt the fact just stated. To such we will simply refer to that apparently extinct art, as regards architects, i.e. bridge-building, and ask, where is the building which can compare with the engineering advance made in the bridges of the Menai Straits, by which the names of Telford and Stephenson have become immortalised?

Why architecture should have stood still in modern times is one of the wonders of the age, especially when we consider the increased means of education afforded to the student, as compared with his immediate predecessors. Look at the number of elaborate works, theoretical, practical, and artistic, they have at hand, so as to be able to study and glean the experience and hard work of years, as it were, in so many hours. Where, for instance, could the student of the last generation obtain in an hour's reading such a knowledge of cements and their uses as is contained in the work of General Pasley? And here we would remark how singular it is that, while architecture itself has almost stood still, the literature of it has made giant strides. Its history is marvellously unfolded, as regards the past, and forms a strong and marked contrast to the want of history in the present period; unless, indeed, a record would find its mission in the extraordinary public-house and music-hall abortions of tricky ornamentation, sometimes clever, but mostly monstrous in all their features. But as the darkest of the night is

before the morning, so we may possibly look for the new "ORDER" out of this chaos.

Why have we not gone on producing varieties of style, as our ancestors did? Simply because, from the time it became fashionable to travel in foreign parts, the architecture of foreign countries, so utterly unfit for the requirements of the climate, or the light and shade, of our own, has been slavishly substituted, to the utter ruin of Britain as an independent producer of building design. When we allude to climate and light of southern countries being wrong, as to copying buildings for ours, we say that, from their excessive light, they want heavy, shaded buildings, while we, from our lack of it, want exactly the contrary; while they only require the flat roof of rainless and snowless countries, we require the acute forms of high-pitched roofs, to throw off the enormous quantity of wet falling in one shape or another. Their flat roofs were, and are, from people using them, indeed almost living on the housetops, literally surrounded by ornamental parapets; in ours, the absence of this feature gives freedom for the rain and snow to escape.

We cannot, in fact, get rid of the principles of truth to nature, unless by the use of the most costly expenditure and of waste, both in material and time. In our ancient street architecture, the ends of roofs fronted the street; and every one knows the beautiful effects of sky line produced by many wonderfully ornamented gables. And besides this, there was the marvellous shadows consequent upon the light passing between roof and roof, all aided by one of the most beautiful and quaint designs of that wonderful feature both in fact and in feeling, but of which modern art seems to be ashamed,—the ancient chimney head.

Well, look to any of our modern streets, and their straight monotony of sky line, so utterly wearisome to the

eye of the artist, and, for all that, to the uneducated in art, who all feel the want of variety, though they cannot express it. After looking at this straight southern country line, without any beauty of parapet, the uninitiated might fancy the roofs behind corresponded in form; but if they go to the house-top, assuredly they will find the old form of sloping roof hid behind the straight line in front, where there is often a large amount of material actually wasted, in order to produce the monotony of a straight line.

Our modern street roofs often present summary and practical proofs of their unfitness for our climate. Does a pipe get stopped up, there is the inevitable flood internally; or in winter, after a moderate fall of snow, there is the gutter spadesman for the external cure. He who, passing by at the time, escapes his falling presents, is indeed fortunate. When our roofs were under the old gabled system, such performances of the "Winter's Tale" comedy were unknown. The snow where it rested was picturesque without, and a source of warmth within.

The question is not now, what limits of knowledge should be attained by an architect to qualify himself for his profession, but what studies or subjects he should not be master of, as almost necessary adjuncts to the numberless and intricate matters forced upon him in daily practice. Beginning with the titled A, he should be thoroughly acquainted with acoustics; for how is it possible for a building to be designed in the proper form and manner necessary for the orator to speak or his hearers to hear with comfort, unless the designer understands completely the theory and practice of this most important science?

So, starting from the beginning, and going through the alphabet, there is scarcely an art or a science with which the architect ought not to be in some measure

acquainted, the more intimately, of course, the better. He ought, in fact, to become a living cyclopædia to be in any way considered a thorough master of a profession in which he can never finish his education, nor ever cease to be a student, because the art and its accessories are always expanding, and of necessity always changing as new appliances are added.

Taking the study of metallurgy alone, the single metal iron, in its different phases, at present enters so largely into architecture, that a close study of its powers and properties has become a necessity. Some professional men are for the use of wrought iron, or iron in its fibrous condition, while others are in favour of the cast or crystalline condition of the material. Both may be right, and both may be wrong, in their excessive adherence to their own views; but there are certain laws of nature defining the powers and limits of things, and these laws prevail even with so hard a material as iron. The cast metal in one situation, that is, at rest, is the most powerful and enduring, but for sustaining the wear and tear of weights in motion, where the vibration requires the spring and elasticity of the fibrous texture, it is exactly the reverse.

Wrought or fibrous iron for *external* purposes, such as railings or ornamental decorations, or in any position of actual rest, will not last one quarter the time of cast metal. The same condition of iron when kept in a constant state of vibration, such, for instance, as railway bars, with trains continually passing over them, furnishes a convincing proof of this. Ample proof of preservation and decay, side by side, may be seen on miles of railway in England, where the narrow and broad gauge run together, and where the active and incessant use of the first shows its perfect condition, while the last is in a passive condition of obvious decay. We here see the truth, that it takes longer to wear out than to rust out.

Iron, as a material for ornamentation in its condition of cast metal, has not yet had a fair trial, and the whole feeling hitherto seems to have been in favour of wrought ornamentation, on account of its capability of artistic form by the hammer and file. But has it any real advantage in this respect over the crystalline form? Is not the skilful designer and modeller as much an artist as the worker in wrought metal, and, as a consequence, is not the result of his work in a casting quite equal to the hammerman's production?

The production of the first cast or impression is as costly as the wrought example, but the repetition of castings or impressions at one-tenth, or perhaps a twentieth part of the cost, just as in the case of an engraving, soon tells the tale in favour of the latter. And, as in the case of an engraving, if it is a work of art, no repetition can affect its value adversely. The question of quantity with equal quality and lasting power of material, must ultimately prevail. There is one point, at any rate, where cast iron stands pre-eminent, and that is its endurance under the action of fire in buildings. And we believe time and improved processes will render it equally pre-eminent in other respects, and especially artistically. In its comparatively moderate cost, we must look for all great extensions.

What wonderful progress in modern times has been made in the production of cast iron, and what equally astounding progress has been made in the manipulation of glass! The advent of these increased powers, by which size, enormous dimensions, and variety of form have been rendered mere questions of cost, would seem to indicate that a new style of art, or, as we should say, of architecture, ought to have sprung from such accessions.

And so we believe it would, and will, whenever the

great body of architects are permitted to go forward, unfettered by the past, excepting as to spirit and fitness. Looking how completely the use of iron is rapidly annihilating both the ancient forms and materials of naval architecture, and the inroads it is more than threatening against her military sister, it does seem strange that the civil architect should not have achieved some great advance, which the addition of glass to iron renders so much easier of application than in the case of either ships or fortified places. We wait for a result. When will it be allowed to come? Or shall we continue to change back again, as fashions do, to some of the architectural unfitnesses of a former age?

The position of the architect, if he practise as an artist, is full of difficulty as to his ultimate success financially. No matter what the trade or profession be, the single-handed necessarily limits his income to the results of his own hand, and when that fails all goes. It would therefore seem little to be wondered at that the architect should extend his practice to become a manufacturer, and to amass wealth, as other commercial men do.

But on the other hand, the architect who carries his own work *through*—and by this, we mean he who creates his own plans and working drawings, writes his own specifications, superintends his own buildings, and so, remaining master of the situation from first to last, devotes himself to a life of hard labour, in which he must exercise moderation in his expenses, and never let them equal his income,—will not erect so many buildings as his commercial brother, but he will, in all probability, retire at the end with a moderate competency, and a reputation against which no one can challenge an appropriation, such, for instance, as occurred in the recent and still unsettled controversy anent the Houses of Parliament at Westminster.

There is one thing in the practice of architecture which operates strongly, and often very prejudicially, against the profession, and that is, the system of payment by an universal and uniform percentage upon the cost of a building. Many an employer is notably prejudiced against a system which involves the interest of the employed in this manner—that instead of the designer receiving an amount in proportion to the work done, and the experienced assistance given, so making his interest identical with that of his employer, the amount of remuneration received by the architect is governed by the amount his client can be induced to expend upon the building.

The adoption of a system of payment by time, charged according to the experience of the professor whose personal interest it ought to be to save the employer all unnecessary cost, is a very serious question, involving one of the many reasons for the non-employment of architects.

It is a curious anomaly that there is a profession, *and only one*, where the most refined knowledge and practical experience are paid at exactly the same rate as that awarded to the merest tyro whose capabilities have yet to be tested. No amount of talent is to receive more than one percentage, and no quantity of mediocrity less.

The immovable five per cent. on the cost, too, is just at the same rate for all drawings and other preparations, whether the building be erected of mud or marble, and whether it be the production of the greatest mind, or the merest effort of inanity. We instance, as a parallel, the utter absurdity of Van Daub, the inexperienced brush, receiving exactly the same amount as the accomplished Van Dyck, for the simple reason that both portraits covered the same amount of canvas. Quantity without quality is not worthless here, at any rate.

In illustration, it may be stated, that there occurred some years ago a remarkable law case, depending upon the custom of the professional five per cent. It was with reference to a large club house, where, the designs and working drawings supposed to be complete, the original estimates were taken as for elevations executed in cement. Eventually, a much more costly material was decided upon, and this, as it was urged, did in no way render the drawings more troublesome to the architect. The professional man brought his action for the usual percentage upon the superior material, and by the old custom gained his cause. If the material used had been of gold, with precious stones amongst the mortar, the architect would have been equally (by custom) entitled on the whole cost. If a percentage on most costly material is a proper charge by the architect, and only sufficient for the skill and labour spent, the same rate of percentage for the same designs executed in very cheap material must be insufficient. And so it often is; but the inequalities named under this head are, nevertheless, great reasons why architects are not more frequently employed.

The circumstances attending this case will be most fatal to architectural employment in the future; more than one member of the club committee came to the decision to never employ architects again, unless under the circumstances of fees in exceptional cases. Small are the requirements of mankind when they employ talent for their necessities only, and not for their luxuries.

One more monstrous absurdity in architectural practice, before we close our present labour. It is the fact of gross inequality of payment to the professor, arising from the different nature of buildings. Thus a payment of five per cent. upon the cost of a long line of plain prison walling, appears a monstrously liberal amount, earnable by the

lowest of talent; while the same rate of percentage upon an elaborately decorated church, with all its minute fittings, screen work, and finishings, would hardly give the architect the living of a hedge carpenter.

All this inequality, for the ultimate good of the profession, ought to be changed; for, however honourable a man may be, his direct worldly interest should be that the cost of a building should be as much, and not as little, as possible.

Regarding the professional status of architects as indexed by the leading society in England, it may fairly be asked whether the great body does or does not lower its position by the encouragement of amateurs in high places of office; and when we look to the example of kindred societies, whether artistic or mechanical, it does seem that there is injury done by substituting wealthy amateurs for professional men, in the higher places of honour. Take the presidency of any other society of artists than the architects, and where is the leading man other than of their own profession? Do we see it in the president of the Royal Academy? or, nearer to our point, is the amateur, however eminent in worldly position, allowed to assume the post of honour in the great Society of Civil Engineers? Assuredly not. If the President of the Royal Academy is not always the greatest of living British painters, he is at all events a great artist; and besides that fact, he generally possesses the faculty of literary address and knowledge to justify both his position and the selection of his brother artists. Look at the published addresses of the Royal Academy presidents, and say where among the amateur heads of architects such things exist in any degree worthy of comparison.

Another cause for depression in the architectural world arises from the very serious course lately adopted by our own government with regard to competitions: we mean in

limiting them to the favoured few, instead of renewing the opportunity for a contest open to all, such as was the case with the Houses of Parliament at Westminster. The state of art at the period was on that occasion fairly developed, if not entirely so; but at any rate the contest was general, and every artist had his chance of success. Those who did not succeed could in most instances very plainly see why, and would naturally go back to gain fresh knowledge against the opportunity of some great national structure requiring all the ability of the period.

That next opportunity has occurred twice, and how have the occasions in both cases been treated? There was no open competition, which would doubtless have developed an amount of ability both as to design and arrangement vastly in advance of the Parliament Houses, in that the number of professors of high standing is notoriously and admittedly increased. Common justice to the profession demanded that the highest ability should be brought forth by a competition of all comers, so that the opportunity of selection should have been from the educated hundred, instead of being from the favoured units, who, whatever their individual merits, have not proved their qualifications to be beyond those of their neglected brothers in art. The results of such limited and favoured competitions for great national works, is indeed disastrous to a profession which has no opportunity excepting these unfrequent national occurrences for testing their power, either in the path of advance or of decadence. And this course is surely hardly consistent with the spirit of free trade, so openly professed and enforced in all matters of commerce, but is strangely and unjustly restrictive, and obviously repressive in matters relative to the architecture of our public buildings.

Never, perhaps, in the time of living men shall we see such opportunities for ascertaining the cost of competition

of the favoured few, and the great ability of the unfavoured many, as occurred in the cases of designs being required for the National Gallery, and for the National Courts of Law. They were both great questions of art, demanding all the knowledge of the age to bring out ability wherever it existed, in order to obtain a grand solution; and there is no telling which has lost most by the result, the nation, by its public discouragement of the most ancient and lasting of the arts, or the profession itself, by its silent concurrence in so fatal a policy.

THE DATES OF THE VARIOUS STYLES OF ENGLISH ARCHITECTURE.

ANGLO-ROMANESQUE.

1. Early British or Anglo-Saxon.
2. Ante-Norman, about 950 to the Conquest.
3. Norman, 1066—1170.
4. Transition, 1170—1200.

GOTHIC.

5. First pointed, 1200—1240 (*Early English*).
6. Late or florid first pointed, 1240—1270 (*Geometric*).
7. Geometric mid dle pointed, 270—1330 (*Geometric or Early Decorated*).
8. Complete middle pointed, 1330—1380 (*Flowing Decorated*).
9. Third pointed, 1380—1485 (*Perpendicular*).
10. Florid third pointed, 1485—1546 (*Tudor*).
11. Elizabethan, 1546—1650.
12. Various modifications of "Renaissance" and Italian, 1650 to the present time.

VAULTING.

UNDER this name I should wish to treat upon the various methods of covering in, or protecting from the weather, any space or building, the principle of the arch being necessary, in all cases, in order to form a vault.

The subject has been so admirably and exhaustively treated by Professor Willis in his learned paper published in the Transactions of the Royal Institute of British Architects, 1842, "On the Construction of the Vaults of the Middle Ages," and in the "Dictionnaire Raisonné de l'Architecture Française," articles "Construction," tom. iv., and "Voûte," tom. ix., that I must refer my readers, who wish to extend their researches beyond the limits of this short article, to those before-mentioned works.

A vault, being in its true and most significant sense a covering to a building, cannot be entirely treated or written upon, as distinct from the walls or piers that support it; the whole must be considered together,—so much so that the whole style of the architecture of any given period may be said to be governed by its method of roof-covering.

The Greeks, borrowing as they did their arts and sciences from the Egyptians, made the lintel the key-note to the whole of their construction. The Romans, being constructors in the truest sense of the word, used the arch in all their buildings; and they are the inventors of

the vault and the dome, or, if not the inventors of the principle, they were the people who first used this form of construction in a scientific manner.

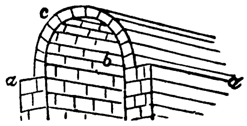


Fig. 1.

The barrel or waggon vault may be described as a continuous arch, with a thrust extending the whole length of its existence, as sketch: examples of this kind of work may be found in the baths of Antoninus, and of Diocletian, and in the basilica of Constantine at Rome; and in England, of Norman date, the aisles of Kirkstall, and under the Bishop's Palace at Norwich; in Ireland, at King Cormach's Chapel, on the Rock of Cashel.

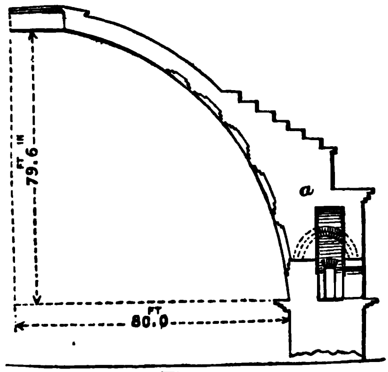


Fig. 2.

These barrel or waggon vaults were of two kinds; the first when they formed the true roof-covering, and the second when they formed the ceiling of the building, and were covered by a wooden roof.

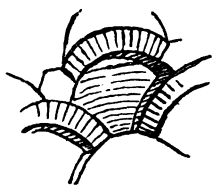


Fig. 3.

The finest example of the domical covering is the Pantheon at Rome; and a section, taken from the Dictionary of M. le Duc, I append, Fig. 2. The surrounding wall is in this case carried up to the level *a*, and pierced with a surround-

ing gallery. In this, and in all buildings of the time, the weight or thrust of the dome was carried from point to point by a series of arches in the dome itself, as at Fi.. 3.

In later times of the Empire, when the constructors became more negligent, this precaution was neglected, and as at St. Sophia, Constantinople, with speedy failure.

The barrel or waggon vault, the original roof-covering of the English buildings of the twelfth century, from being entirely continuous, in course of time, and as the exigences of the case required, gradually grew into a more complicated system of construction. The first alteration of its continuity would be, when it was necessary to form an opening above the springing, as at Fig. 4.

The next step in forming a vaulted covering was a copy of, or similar to, the Roman groin, which is simply the interpenetration of two plain curved surfaces, without ribs at the intersection of the curves, as may be seen in the crypts of Westminster and other cathedrals, and in the keep of Rochester Castle. The ribbed vaulting of the Middle Ages, when the thrust is thrown down to certain points or piers, consists of stone arches thrown transversely and diagonally, and filled in between the spandrels with the real vaulting or ceiling.

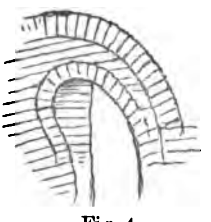


Fig. 4.

Upon the adoption, in the thirteenth century in England, and the twelfth century in France, of this system of thrust and counter-thrust, instead of thick walls resisting the thrust upon them along their whole length, the whole system of building became revolutionized; the pointed arch, which experience soon taught the builders had a more downward thrust than the semi-circular arch, soon came into general use, and from being first used for

constructional reasons, it gradually grew into use throughout the whole building or design.

The first and most simple style of groining, and which may be described as following, Fig. 5 : *a a*, a transverse rib thrown across between two walls ; *b b*, two arches, starting from the same points as *a a*, but carried diagonally,

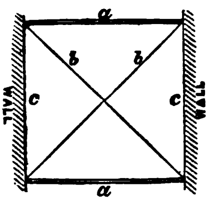


Fig. 5.

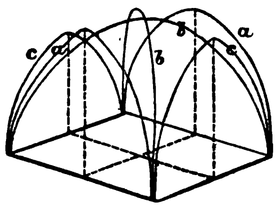


Fig. 6.

and called diagonal ribs ; *c c*, arches built in the thickness of walls, and called the wall ribs. This diagram, if produced in perspective, as Fig. 6, *a a*, transverse rib ; *b b*, diagonal rib ; *c c*, wall rib, is the skeleton upon which the whole system of this method of construction is founded : the space to be covered was not always square, nor could

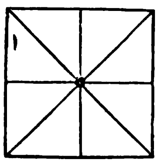


Fig. 7.

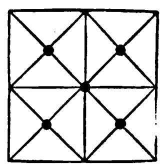


Fig. 8.

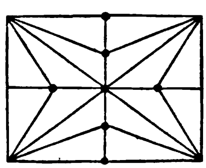


Fig. 9.

it be divided into square bays or divisions ; but in the best periods of mediæval art, this was the principle of setting out the work. The above simplicity of ribs, by the law of progress, the varying exigences of plan, and other reasons that, in a growing art, all tend to produce change, developed a more and more complicated system

of ribs; the square bay or division, with its quadripartite division shown in Fig. 5, soon grew to this (Figs. 7, 8, 9), and, in England, to a more elaborated system, until the ornate styles, called Flamboyant in France, and Perpendicular in England, produced the system called Fan-vaulting; so-called, apparently, from the multitude of ribs starting from each centre of construction, and again interlaced with ribs, sometimes circular, on plan (Fig. 10).

This method, quite different in principle to the early styles, opened a new field to the designers of the time: the interlacing ribs, being circular on plan as on section, enabled them to vary the surface of their ceilings with

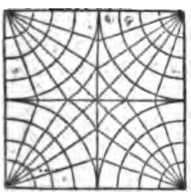


Fig. 10.

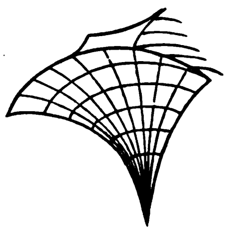


Fig. 11.

pendants, hanging down with apparent recklessness, but really as firmly fixed as the keystone itself by the pressure of the doubly arcatured ribs.

With this new form of construction design seemed to run riot, until, as in the choir of Gloucester Cathedral, where this work is woven, as it were, amongst the Norman Arches, the lace-like grace and beauty is so great that its seeming licentiousness must be forgiven.

Having traced the forms of the ribs throughout their growth, I must now speak of the filling between them that clothes the skeleton of construction and forms a complete ceiling; and I cannot here give a better description of this work than by summarising the masterly

theory of M. Viollet le Duc in the article "Construction" of his invaluable dictionary :—

"In the middle of the provinces comprising the ancient Aquitaine, the method of the builders of the tenth and eleventh centuries was to roof their buildings with cupolas (coupoles). This was so firmly imprinted on their style of work that they were very late in adopting the Gothic style of vaulting.

Fig. 12.

"Every one knows that the rings which compose a cupola give in horizontal projection a succession of concentric circles. . . . .

"At this time the system of Gothic construction prevailed in the royal domains; and in time it was adopted in the western parts of the Continent. Thus, in the earliest groining the filling in between the ribs took the form of the rings of a cupola, thus (Fig. 12); whilst in the Isle of France (the chief centre of activity during the twelfth and thirteenth

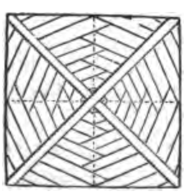


Fig. 13.

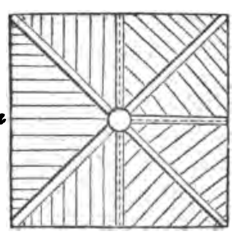


Fig. 14.

centuries of Gothic construction) the following system of filling in was adopted (Fig. 13).

"This method was that adopted in England, but was afterwards abandoned on the Continent; whilst in England it was carried to greater perfection. The plan

adopted on the Continent was as shown in Fig. 14; the half A represents the French or continental system, and the half B the English system.

"The English system being similar to that in use in Aquitaine, which, in the twelfth century, was Anglo-Norman, is the remnant of the feeling for the dome construction; whilst in the Isle of France, where the new or Gothic style was first perfected, the old traditions were completely forgotten."

M. le Duc, by copious illustrations and facts, shows how he has arrived at the conclusion that the dome principle is the most constructional.

ALBERTI ON ARCHITECTURE.

EXTRACTS FROM "THE ARCHITECTURE" OF LEON BATISTA ALBERTI.

Translated by James Leoni, Architect, London, 1755.

In choosing a Region for Building.

"By what marks we are to know the goodness of a region."

. . . . . .

"Thus it will be a good sign of an excellent air and of good water if the country produces plenty of good fruits, if it fosters a good number of men of a good old age, if it abounds in lusty handsome people, if the people are fruitful, and if the births are natural and never monstrous."

. . . . . .

"We may not improbably draw some conjectures from the shapes and looks of other animals; . . for if the cattle look lively, fat, and large, you may not unreasonably hope to have children that will be so too. Neither will it be amiss to gather notice of the air and winds even from other bodies not endued with animal life;

thus, if the walls of the neighbouring buildings are grown lusty and rugged, it shows that some malignant influence has power there. The trees, too, bending all one way as if by general consent, show that they have suffered the force of high rough winds."

. . . . . .

Treating of the Materials.

That no man ought to begin a Building hastily.

"I do not think the labour and expense of a building ought to be entered upon in a hurry; as well for several other reasons as also because a man's honour and reputation suffer by it. For as a design well and completely furnished brings praise to him that has employed his pains and study in the work; so if in any particular the author seems to have been wanting either of art or prudence, it detracts very much from that praise and from his reputation. And indeed the beauties or faults of edifices, especially public ones, are in a manner clear and manifest to everybody, and (I know not how it happens) any thing amiss sooner draws contempt than anything handsome or well finished does commendation. It is really wonderful how by a kind of natural instinct all of us, knowing or ignorant, immediately hit upon what is right or wrong in the contrivance or execution of things; and what a shrewd judgment the eye has in works of this nature above all the other senses. Whenever it happens that if anything offers itself to us that is lame or too little, or unnecessary, or ungraceful, we presently find ourselves moved, and desirous to have it handsome."

. . . . . .

"By making a model you will have an opportunity

thoroughly to weigh and consider the form and situation of your platform, with respect to the region, what extent is to be allowed to it, the number and order of the parts, how the walls are to be made, and how strong and firm the covering. . . . . And then you may easily and freely add, retrench, alter, renew, and, in short, change every thing from one end to the other; till all and every one of the parts are just as you would have them, and without fault."

• • • • • •

What Materials are to be provided for the Building.

"And in fixing upon all these, it will be of use to you to be somewhat guided by the consideration of other works already finished in your neighbourhood, and by the information you receive from them to determine what to do in your own case."

. . . . . .

"The ancients inform us that most trees, and especially the fir, the pitch tree, and the pine, ought to be cut immediately when they begin to put forth their young shoots, when through their abundance of sap you most readily strip them of their bark. But that there are some trees, as the maple, the ash, and the linden, which are best cut after vintage. The oak, if cut in summer, they observe, is apt to breed worms; but if in winter, it will keep sound and not split. And it is not foreign to our purpose what they remark, that wood which is cut in winter will nevertheless burn extremely well, and in a manner without smoke; which, manifestly shows that their juices are not crude, but well digested. Vitruvius is for cutting timber

from the beginning of autumn till such time as the soft westerly winds begin to blow."

. . . . . .

Of preserving the Trees after they are cut.

"After the timber is cut it must be laid where the searching heat of the sun or rude blasts of wind never come. . . . . . Nor will I omit what we read in *Aulus Gellius*, taken out of the annals of *Quintus Claudius*, that *Archelaus Mithridates*, Prefect, having thoroughly bedaubed a wooden town in the Pieræum with alum, when Sylla besieged it, it would not take fire."

. . . . . .

What Woods are most proper for Building, their Nature and Use, &c.

"Throphrastus thinks that timber is not dry enough for the making of planks, especially for doors, in less than three years. . . . The alder, for piles, to make a foundation in a river, or on marshy ground, exceeds all other trees, and bears the wet incomparably well, but will not last at all in the air or sun. On the contrary, the beech will not endure the wet at all. The elm, set in the open air, hardens extremely, but else it splits and will not last The pitch tree and pine, if buried under ground, are wonderfully durable: but the oak, being hard, close, and nervous, and of the smallest pores, not admitting any moisture, is the properest of any for all manner of works under ground; capable of supporting the greatest weights, and is the strongest for columns."

. . . . . .

"If the ancients had occasion to turn anything long and round, they used the beech, the mulberry, the tree that yields the turpentine, but especially the most close bodied box, most excellent for turning; and for very curious works, the ebony. Neither for statues or pictures did they despise the poplar, both white and black, the sallon, the hornbeam, the service tree, the alder, and the fig. . . . . Though it is certain that none of them, for tractableness, can compare with the linden. Some there are that for statues choose the jubol-tree. Contrary to these is the oak, which will never join, either with itself or any other wood of the same nature, and despises all manner of glue. The same defect is supposed to be in all trees that are grained, and inclined to distil. Wood that is easily planed, and has a close body, is never fastened with glue; and those also that are of different natures, as the ivy, the laurel, and the linden, which are hot, if glued to those that grow in moist places, which are all in their natures cold, never hold long together. The elm, the ash, the mulberry, and the cherry tree, being dry, do not agree with the plum tree or the alder, which are moist. Nay, the ancients were so far from joining together woods different from each other in their natures, that they would not so much as place them near each other; and for this reason Vitruvius advises us against joining planks of beech and oak together.

. . . . . .

Of Stones in General, . . . which are the softest, and which the hardest, and which best and most durable.

"Cato advises to dig the stone in summer, to the intent that it may grow accustomed, by degrees, to wind, rain,

and frost, and other inclemencies of the weather which it had not felt before. For if stone immediately upon its being dug out of the ground whilst it is full of its native juices and humidity, is exposed to severe winds and sudden frosts, it will split and break to pieces. . . . . They should not be used under two years, to the intent that you may have time to find out such among them as are weak in their natures, and likely to damage the work, and to separate them from the good ones; for it is certain, in one and the same kind of stones there is a difference in goodness of any sort of stone, and its fitness for this or that peculiar situation is best learnt from use and experience; and you may much sooner come at their values and properties from old buildings, than from the writings and precepts of philosophers. However, to say something briefly of stones in general, we will beg leave to offer the following observations.

"All white stone is softer than red, the clear is more easily wrought than the cloudy, and the more like salt it looks the harder it is to work. Stone that looks as if it were strewed with a bright shining sand, is harsh; if little sparks, as it were of gold, are intermixed, it will be stubborn; if it has a kind of little black in it, it will be hard to get out of the quarry. That which is spotted with little angular drops, is sharper than that which has round ones, and the smaller these drops are the harder it will be, and the finer and clearer the colour is, the longer it will last. The stone that has fewest veins, will be most entire, and when the veins come nearest in colour to the adjoining parts of the stone, it will prove most equal throughout. The smaller the veins the handsomer; the more winding they run, the more untoward; and the more knotty the worse. Of these veins, that is most likely to

split which has in the middle a reddish streak, or of the colour of rotten ochre. Much of the same nature is that which is stained here and there with the colour of faded grass; but the most difficult of all is such as look like a cloudy piece of ice. A multitude of veins shows that the stone is deceitful and likely to crack, and the straighter they are the more unfaithful. Upon breaking a stone, the more fine and polished the fragments are, the closer body it is; and that which when broken has its outside the least rugged will be more manageable than that which is rough. Of the rough ones, those which are whitest will be worst for working, whereas on the contrary in brown stones those of the smallest and finest grain are least obedient to the tool. All uneven ordinary stones are the harder for being spongy, and that which being sprinkled with water is the longest drying, is most crude.

"All heavier stones are more solid and easy to polish than light ones; which, upon rubbing, is much more apt to come off in flakes than such as are heavy. That which, upon being struck, gives the best sound is closer made than that which sounds dull; and that which, upon strong friction, smells of sulphur is stronger than that which has no smell at all. Lastly, that which makes the most resistance against the chisel will be the most firm and rigid against the violence of storms.

"They say, that the stones that hold together in the largest scantlings at the mouth of the quarry are firmest against the weather. All stone too is softer when it is just dug up, than after it has been some time in the air; and when it is wetted or softened with water is more yielding to the tool than when it is dry. Also, such stones as are dug out of the moistest part of the quarry, will be

the closest when they come to be dry, and it is thought that stones are more easily wrought in a south wind than in a north; and are more apt to split in a north wind than in a south. But if you have a mind to make an experiment how your stone will hold out against time you may judge from hence. If a piece of it, which you soak in water, increases much of its weight, it will be apt to be rotted by moisture, and that which flies to pieces in the fire will bear neither sun nor heat."

. . . . . .

Of the Origin of the Use of Bricks, in what Season they ought to be made, and in what Shapes, &c.

"Our business is to observe here, that a white chalky earth is very much recommended for making them. The reddish also is approved of, and that which is called male sand. That which is absolutely gravelly and sandy is to be avoided, and the stony most of all; because in baking it is subject to warp and crack, and if oven baked it will fret away of itself. We are advised not to make our bricks of earth fresh dug, but to dig it in the autumn and leave it to digest all the winter, and to make it into bricks early in the spring; for if you make it in winter, it is obvious that the frost will crack it; and if you make it in the middle of summer the excessive heat will make it scale off in drying. But if necessity obliges you to make it in winter, in extreme cold weather, cover it immediately over with very dry sand, and if in summer with wet straw, for being so kept, it will neither crack nor warp.

"Some are for having their bricks glazed: if so, you must take care not to make them of earth that is either sandy,

or too lean, or dry, for these will suck and eat away the glazing. But you must make them of a whitish or fat clay, and you must make them thin, for if they are too thick they will not bake thoroughly, and it is a great chance but they split; if you are obliged to have them thick, you may in a great measure prevent that inconveniency if you make one or more little holes in them about half way through, whereby the damp and vapour having proper vents, they will both dry and bake better.

"The potters rub their vessels over with chalk, by which means the glazing, when it is melted over it, makes an even surface; the same method may be used in making bricks. I have observed in the works of the ancients that their bricks have a mixture of a certain proportion of sand, and especially of the red sort, and I find that they also mixed them with red earth, and even with marble. I know by experience that the same earth will make both harder and stronger bricks, if we take the pains to knead every lump two or three times over, as if we were making of bread, till it grows like wax, and is perfectly free of the least particle of stone. These, when they have passed the fire, will attain the hardness of a flint, and whether owing to the heat in baking or the air in drying, will get a sort of strong crust as bread does. It will, therefore, be best to make them thin that they may have the more crust and the less crumb. And we shall find that if they are well rubbed and polished, they will defy the fury of the weather. The same is true of stones that are polished, which thereby escape being eaten with rust. And it is thought that bricks should be rubbed and ground either immediately upon their being taken out of the kiln, before they are wetted, or when they have been wetted before they are dry again; because when once they have been wetted

and afterwards dried, they grow so hard that they will turn and break the edge of the tools, but they are easier to grind when they are new and hardly cold."

. . . . . .

Of the three different Kinds of Sand, and of the various Materials in Building in different Places.

"There are three sorts of sand, pit sand, river sand, and sea sand. The best of all these is pit sand, and this is of several kinds, black, white, red, the carbuncly, and the gritty. . . . . . .

"Of all these they commend the carbuncly the most. I have observed that in the public buildings of Rome they used the red as none of the worst. Of all the pit sand, the white is the worst. The gritty is of use in filling up the foundations, but among the best they give the second place to the finest of the gritty, and especially to the sharp angular sort, without the least mixture of earth in it. Next to this they esteem the river sand, which is dug after the upper layer is taken off; and next to the river sand that of the torrent, especially of such torrents as run between hills where the water has the greatest descent. In the last place comes the sea sand, and of this sort the blackest and most glazed is not wholly to be despised. . . There is a great deal of difference in sands, for that of the sea is very slow in drying, and is continually moist and apt to dissolve by reason of its salt, and is, therefore, very improper and unfaithful in supporting great weights. That of the river, too, is somewhat moister than the pit sand, and therefore is more tractable, and better for plastering work . . . But of each sort, that is always best which being rubbed in the

hand crumbs the most, and being laid upon a white cloth makes the least soil, and leaves the least earth behind it On the contrary, that is the worst which feels mealy instead of sharp, and which in smell and colour resembles red earth, and being mixed with water, makes it foul and muddy, and if left abroad in the air presently brings forth grass. Neither will it be good which, after it is dug, is left for any time exposed to the sun, or moon, or frosts."

. . . . . .

That the Foundation is no Part of the Wall; what Soil makes the best Foundation.

"The foundation, if I mistake not, is not properly a part of the wall, but the place and seat on which the wall is reared. For, if we can find a seat perfectly firm and solid, consisting, perhaps, of nothing but stone, what foundation are we obliged to make? None, certainly, but to begin immediately from thence to erect our wall. At Siena there are huge towers raised immediately from the naked earth, because the hill is lined with a solid rock. Making a foundation, that is to say, digging up the ground and making a trench, is necessary in those places where you cannot find a firm ground without digging, which, indeed, is the case almost everywhere, as will appear hereafter. The marks of a good soil for a foundation are these: if it does not produce any kind of herb that usually grows in moist places; if it bears either no tree at all, or only those that delight in a very hard close earth; if everything round about it is extremely dry, and as it were quite parched up; if the place is stony, not with small round pebbles, but large sharp stones, and especially flints; if there are no

springs nor veins of water running under it; because the nature of all streams is to be perpetually carrying away, or bringing something along with them. And, therefore, it is that in all flat grounds lying near any river you can never meet with any firm soil till you dig below the level of the channel. Before you begin to dig your foundations, you should once again carefully review and consider all the lines and angles of your platform, what dimensions they are to be of, and how they are to be disposed."

• • • • • •

Of the Nature, Forms, and Qualities of Stone, and of the Tempering of Mortar.

"All stone should be entire, not muddy, and well washed. You may know whether it is entire or cracked by the sound it gives when you strike upon it. You can wash them nowhere better than in a river, and it is certain that the middling sizable sorts are not soaked enough under nine days, and the larger ones under more. That which is fresh dug out of the quarry is better than that which is long kept, and that which has been once cemented with mortar, will not cement well again a second time. So much may suffice as to stone."

• • • • • •

Of Coverings of Straight Lines, of the Beams and Rafters, and of the uniting the Ribs.

"We will first, according to our custom, mention one observation which relates in general to all sorts of coverings; which is this: that all manner of roofs and coverings have their ribs, nerves, finishings, and shells or crusts, just

the same as the wall, which will appear from the consideration of the thing itself. To begin with those of wood, and consisting of straight lines, it is necessary for supporting the cover to lay very strong beams across from one wall to the other, which, as we took notice before, are columns laid transverse. These beams, therefore, are a sort of ribs. . . . Between these we lay the cross beams, rafters, and the like, which may not at all improperly be reckoned the ligatures; to these we fit and join boards and planks of greater breadth, which there is no reason we should not call the finishing. . . . First take notice of one thing not foreign to our purpose. There is a very vicious practice among our modern architects, which is, that in order to make their ceilings, they leave great holes in the very ribs of the building to let the heads of the beams into after the wall is finished, which not only weakens the structure, but also makes it more exposed to fire, because by these holes the flames find a passage from one apartment to another. For which reason I like the manner used among the ancients of setting in the wall strong tables of stone, called corbels, upon which they laid the heads of the beams."

. . . . . .

"The beams ought to be perfectly sound and clear, and especially in the middle of its length it ought to be free from the least defect. Placing your ear at one end of it whilst the other is struck, if the sound comes to you dead and flat, it is a sign of some private infirmity. Beams that have knots in them are to be absolutely rejected, especially if they are in a manner crowded together in a cluster. The side of the timber that lies nearest the heart must be planed, and laid uppermost in the building, but the part that is to lie undermost must be planed very

superficially, only the bark, nay, and of that hardly any, or as little as possible. Whichsoever side that has a defect that runs crosswise to the beam lay uppermost; if there is a crack longways never venture it at the side, but lay it uppermost, or rather, undermost. If you have occasion to bore a hole in it, or any opening, never meddle with the middle of its length, nor its lower superfices. If, as in churches, the beams are to be laid in couples, leave a space of some inches between them that they may have room to exhale, and not be spoiled by heating one another. And it will not be amiss to lay the two beams of the same couple different ways, that both their heads may not be upon the same pillow, but where one has its head the other may have its foot; for by this means the strength of the one's foot will assist the other's head, and so *vice versa.*"

• • • • • •

Of Private Houses and their Differences, &c.

"I now come to treat of private edifices. I have already observed elsewhere that a house is a little city. We are, therefore, in the building of it to have an eye to everything that relates to the building of a city, that it be healthy, furnished with all manner of necessaries, not deficient in any of the conveniences that conduce to the repose tranquillity or delicacy of life. What these are, and how they are to be obtained, I think that I have in a great measure shown in the preceding books. However, as the occasion here is different, we shall consider them over again in the following manner: A private house is manifestly designed for the use of a family, to which it ought to be a useful and convenient abode. It will not be so convenient as it ought if it has not everything within

itself that the family has occasion for. There is a great number of persons and things in a family, which you cannot distribute as you would in a city so well as you can in the country. In building a house in town, your neighbour's wall, a common gutter, a public square or street, and the like, shall all hinder you from contriving it just to your own mind, which is not so in the country, where you have as much freedom as you have obstructions in the town. For this and other reasons, I shall distinguish the matter thus: That the habitation of a private person must be different in town from what it is in the country. In both these there must be again a difference between those which are for the meaner sort of citizens, and those which are for the rich."

Our author then goes on to describe with much minuteness the requirements of a country house, and also of a town house, every sentence being full of wise suggestions, especially when they are evidently the fruit of his own experience, and not borrowed merely from the ideas of the ancients.

These extracts have been of necessity torn out from the main structure of the work, and it has been only possible, in the space of this small book to give some of the practical facts that Alberti deduces, leaving out in most cases the powerful arguments that he brings to bear to prove his facts. I can only, therefore, give enough to create a relish for the work, hoping that I have not done my selection in such a manner as to maim the sense and destroy the appetite of the reader for a further study; and I earnestly recommend that all who are interested in any

way in the study of architecture, including even "those about to build," to obtain a perusal of it. Those who possess the book amongst their collection will, perhaps, forgive me if I have been the means of pointing out its use and its beauties; and those who have it not, will, I hope, endeavour to see it and study it well at some of our large public libraries.

It may interest some of my readers to know that Leon Batista Alberti was supposed to have been born at Venice, in the year 1404. He wrote much, and on varied subjects, but the works which are most highly esteemed are those on the arts.

His principal buildings appear to have been the Church of Saint Andrea, at Mantua; the Malatestan Church, at Rimini; the Racellaj Palace, at Florence; the Choir and Tribune of the Church of the Annunciation, also at Florence, and, quoting from "Rose's Biographical Dictionary," "the form is circular, about sixty-six feet in diameter, surrounded by nine large niches sunk in the thickness of the outer wall, which gives an extreme diameter of ninety-three feet." . . .

Alberti seems to have united in his own person all those requirements which Vitruvius thought necessary to constitute a perfect architect; and he had this advantage over the Roman, that he left to posterity works which fully realised those principles of science and taste which he promulgated in his "De Re Edificatoria."

SHADE AND SHADOW-CASTING, OR SCIOGRAPHY.

The art of casting shadows correctly upon an elevation, is so important in giving a reality to the work, and is, at the same time, so little understood or practised correctly in England, that a short and easy method of attaining this object, must be of great use to the student in architecture.

For the purpose of our essay it will be sufficient to state, that all objects to be represented must be considered to be:—in *light* when the rays of light fall upon them without obstruction; in *shade* when another object intercepts the rays of light; and in *shadow* when the object, intercepting the rays of light, throws a defined darkness upon the object by the direct action of the rays. The outline of a *shadow* must, therefore, be bounded by a surface or surfaces in *light*.

An object in *shade* is in that state from being deprived of the direct rays of light, and the shade will have no outline of itself. The conditions of this state of shade are variously affected, by texture, from a reflected light. No book can teach this so effectually as observation of natural objects, of the truth of which the following illustration will suffice.

Supposing that we wish to *shade* a portion of a column, (Fig. 1), common sense would teach us that in a circular surface there must be one part, that of the surface, that is brighter than the rest, and from that point the light will diminish and the shade strengthen, so that if the highest point of light is at A (Fig. 2) the light will diminish from that point, in the direction of the arrows. In that case the strongest portion of the shade should be where the two arrows met, say at B. But this would not be the case. Reflected light then comes into force, and the shadow thrown by the object upon any other surface, will reflect back a certain amount of light; thus (Fig. 3), point of light A, diminishing from light to shade, A to C, and C to A; darkest point of shade C; reflected light from the points marked by the tangents E, E, representing the line of the shadow; and represented in elevation only by the parts from C to D.

Fig. 1.

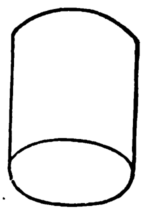


Fig. 2.

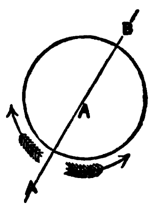
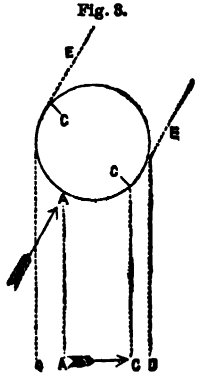


Fig. 3.

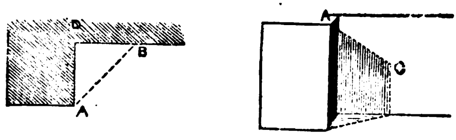


These remarks are intended first to place the student in the path to a knowledge of the subject of shading; he will, if he be an artist in the true sense of the word, have already thought out this subject, and will therefore go at once to the theory of Sciography or the Casting of Shadows.

It is usual in most architectural works to represent the shadows of an object at an angle of 45 degrees with the horizon, and it has this advantage—that this being

found, the breadth of the shadow will give the projection on plan, as can be shown by projecting a shadow from a cube of two diameters in height upon a plane surface, thus: — Fig. 4. (The outline of shadow is shown by a dotted line).

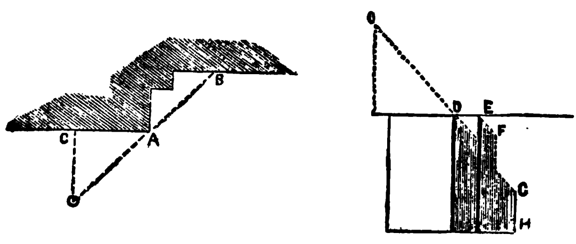
Fig. 4.



The shadow thrown by the angle A, at 45 degrees upon the plane surface at B, is represented upon the sketch at C; the line A, C, thus represents the diagonal of the projection A, D, which can be obtained bv calculation, or the simple method of setting of the diagonal with the set square.

The shadow being thrown on both elevation and plan in the examples here given, to the angle of 45 degrees, the sun will then stand at angle of 35° 10′ with the horizon. This is mentioned to avoid the confusion that might arise. It can be found thus, Fig. 5 :—

Fig. 5.

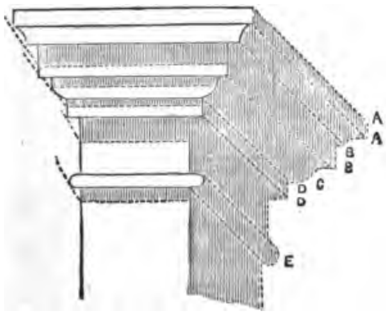


O, the sun, A, B, the shadow on plan, D, E, F, G, H, the

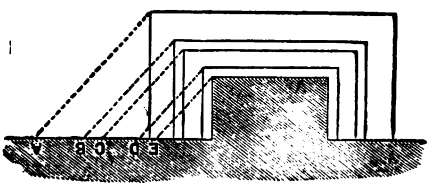
outline of shadow. O, A, being the diagonal of A, C, the true projection of O A on elevation will give the angle of 358 10′.

The following examples will show the principle upon which the forms of shadows are determined :—

Fig. 6.



ELEVATION.



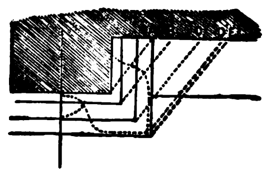
PLAN.

Fig. 6. The various projections, A, B, C, D, and E, are first projected on a surface x, as shown on the plan with dotted lines. The points, when they touch the surface x, are then produced upon the elevation, and then form the same projections on the elevation, carry down lines at the same angle, intersecting with the points taken from the

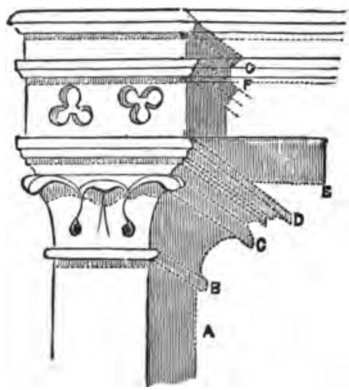
plan, and the points of intersection will give the outline of the shadow.

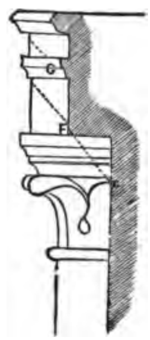
In Fig. 6 and the following the same rules will apply.

Fig. 7.



PLAN.



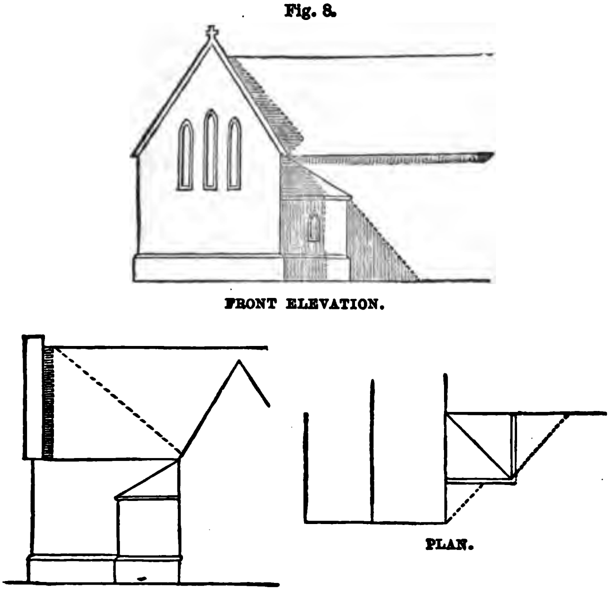


ELEVATION. ELEVATION.

These examples might be multiplied to any extent; but, as the same rule would apply in every case, it would scarcely be required to go further into detail in this small work. The student can, however, be referred to the admirable and exhaustive series of examples given in Gwilt's Encyclopædia of Architecture, to which the author gratefully refers as a most valuable store-house of

information on all subjects connected with the practice of architecture.

Fig. 8.



SIDE ELEVATION.

The French and German draughtsmen, who rely very little upon perspective for their effects, but finish up their elevations in the most elaborate manner, are instances of what beautiful effects may be produced by scientific means; and the drawings of the church of St. Mark, Venice, exhibited at South Kensington Museum, should be studied as well for the correct manner in which the shadows are thrown as for their proper and correct appreciation of ancient art.

A SPECIFICATION FOR A DWELLING HOUSE.

(Written in Blank, showing the usual Method of Description, and Form of Composition.)

Specification of the several artificers' works required to be done in erecting
for   of
according to the various drawings, and under the superintendence of Mr.   , Architect of

---

EXCAVATOR OR DIGGER.

Vegetable Soil.—The whole of the vegetable soil to be removed to where directed, from the whole area of the buildings.

Trenches.—The several trenches for the reception of the footings to be formed of the various depths and widths shown and figured upon the plans and sections; or, if required, to any depth necessary to form a good and solid foundation.

Surplus Earth.—The surplus earth to be deposited around the site, or where may be directed by the Architect.

The footings to all walls to be filled round solid previously to the walls being built up.

Drains.—The trenches for the several drains to be formed in the directions shown on the plan of foundations. The rain water drains in all cases to be carried above the level of the foul water drains where they cross each other.

Concrete.—The concrete for the foundations to be formed of one of lime to six parts of coarse sharp gravel.

BRICKLAYER.

Bricks.—The bricks to be all of equal quality with samples to be deposited with and approved by the architect, and to be, for the outside facing, the best , and for the inside walls and the backing of inside walls, the best .

Mortar.—The mortar to be composed of lime, and good, sharp, clean river sand, in the proportion of two parts of lime to three parts of sand.

Cement.—The cement to be from approved manufacturers, and of the best kind; and in all cases, unless described as neat, to be mixed in equal proportions with clean washed sand.

Damp Course.—Build in at the ground level a double slate damp course the full width of wall, set in cement.

Flues.—Form, parget, and core all flues, and carry down to the level of chimney bars.

Trimmers.—All fireplaces above the basement story to be fitted with trimmer arches in half brickwork in cement

the length of the hearth, and to have a proper skewback in the wall springer.

Set Stoves.—Set all stoves and ranges to the several fireplaces with all necessary bricks, clay, &c.

Sleeper Walls.—The wood floors in basement to have sleeper walls formed in half brick, with one brick for rings, and one foot three inches high, and this space to be preserved under all the wood floors of basement; openings to be left in the sleeper walls to admit of a passage of air between them, and to connect with gratings in the external walls. The fire places of these rooms to have fender walls for hearths, similar to the sleeper walls.

Bed Plates.—Bed all plates, sleepers, lintels, templates, &c., in mortar, and all window and door frames to be bedded in lime and hair, and neatly pointed round.

Chimney Shafts.—The five top courses of chimney shafts are to be built in cement in all cases.

The foul water and soil drains are to be carried in the manner shown with 4 in., 6 in., and 9 in. earthenware socket jointed pipes, set in cement with all necessary bends and junctions and traps.

Generally.—The bricklayer is generally to attend upon all other tradesmen; he is to cut away for and make good after other workmen; bore all holes for plumbers, engineers, bell hangers, &c. He is to point round all plumbers' work where it joins the brickwork, and make good after the smith; to see that all drains and pipes are clear, and that all rubbish is removed at the completion of the works. All the brickwork generally to be overlooked at the completion, all loose joints to be made good, all defective bricks cut out and replaced, all brick dust brushed from the face work.

MASON.

Provide, work, and set with stone of the best quality, the several parts of the building required and shown upon the drawings to be in stone, and to be from the quarries, free from vents, shakes, and all other defects, and to be set on its proper or quarry bed.

Paving.—The passages and other portions coloured blue on the plans to be paved with York stone, rubbed (or chiselled), properly squared and jointed; to be laid in mortar upon brickwork two courses high in regular courses with hoop iron under the cross joints, and the joints to be cleaned off at the completion. A 4 inch thickness of dry rubbish to be formed, upon which the brick foundations of paving are to be laid.

Corbels,—Provide all requisite templates and corbels of rough York stone for the ends of girders bearing beams or partitions, and for plates, &c., to prevent them from entering walls in the neighbourhood of smoke flues.

Steps.—Put to all exterior doors the number of steps shown, to be in rubbed York stone, 9 in. longer than the openings.

Provide and fix upon brick piers a York stone sink, feet long by feet wide, and inches deep, to have a brass bell trap grate, and 3 in. waste to drains.

Fire Places.—Set the whole of the fire places described in the following schedule:

(Here mention the whole of the rooms to be provided with fireplaces, and the amount intended to be spent upon each, unless detail drawings are given with the specification.)

Clean off.—Clean off prior to the completion the whole of the mason's work, and point up all defective joints.

Rectify any damage that may occur during the work. Cover up stone plinths, steps, or elsewhere that may be thought requisite.

CARPENTER.

Materials.—The whole of the fir timber is to be of the best sound Memel or Dantzic, free from shakes, sap, dead knots, or other defects. The deals to be of the best quality seasoned Christiania, free from all defects.

Generally.—Provide all necessary timbers for stays, struts, ties, shores, scaffolding pieces, or other purposes that may be required; and all sufficient centring for arches, turning pieces, templates, moulds, levels, rules, or other things required in the execution of the contract.

Provide, fix, truss, frame, and trim in the most workmanlike manner all roofs and floors of the scantlings marked, and otherwise in strict conformity with the several drawings, and with such further instructions or detail drawings as shall be given by the architect or his clerk of the works.

Slate Battens.—Cover the whole of the roofs with ¾ inch slating battens, and tilting fillets against chimneys and to all eaves.

Gutters and Flats.—Lay inch yellow deal wrought boarding to all the gutters and flats upon proper fir bearers, forming 1½ in. rebated drips, 2 in. rounded rolls to the flats, and large cesspools at the outlets.

Flues, Distance Apart, Trim.—No timbers to be nearer than 12 inches to any flue, and no rafters, quarters, or joists to be a greater distance apart than 12 inches, and trim for all flues when timbers come near to them; all

trimmer pieces to be ½ inch thicker than the other timbers and joists.

Roof Trap.—Trim for and form an inside and outside trap, where indicated on the plan for entrance on to roof.

Plates.—The plates throughout to be halved at the angles, and the joists to be notched on the plates.

Lintels.—Put lintels over all door and window openings; the scantlings to be 1 inch deep for every foot of bearings and the full width of the wall above.

Bond Timber.—No bond timber or other wood work to be laid in the walls, except where necessary for fixing the joiner's work, and no plugs to be driven nearer than 6 inches to any flue.

Partitions.—The partitions to be properly constructed with heads, sills, posts, rails, and quarters of the scantlings marked on them in the plans, the ends to bear upon strong York stone corbels or templates.

Insert rows of herring bone strutting, and ¾ inch rods, with all necessary screws, nuts, heads, and washers, to the floors of rooms.

JOINER.

Generally.—Provide and fix beads, steps, fillets, tilting fillets, backings, blocks, linings, casings, joinings, bearers, bar boarding, &c., and perform all such rebating, grooving, tenoning, scribing, housing, mortising, framing, mitering, dovetailing, planing, and other labours connected therewith, as may be found necessary to properly complete and finish the carpenter's and joiner's work.

Floors.—Lay to the bed-rooms and office floors where coloured yellow on plans inch white deal floors, well

seasoned, laid folding; and to the best rooms inch yellow deal clean picked battens, free from knots, well seasoned, laid straight joint with splayed headings and edges nailed; if any one of the joints open more than $\frac{1}{32}$ of an inch, then those boards must be taken up and relaid.

(In a general specification it would not be possible to describe the remaining portions of the joiner's work, as the description of the construction of the doors, windows, shutters, staircases, closets, skirtings, kitchen fittings, w. c. fittings, cisterns, sinks, &c., must be written for the varied requirements of the design. This subject it is the intention of the author to fully consider shortly in a detailed and exhaustive work.)

PLASTERER.

All the work to be executed in the best and most workmanlike manner with fresh burnt lime, and clean sharp river sand.

Generally.—Bracket out and properly prepare for in the most secure manner the several projections shown to be intended by the drawings. Form all splays, arrises, jambs, and soffits, and make good all defects at the completion.

Walls.—Render flote and set and thrice colour the walls of all rooms and passages in basement (or kitchen and offices), prepare for flatting the hall and staircase, and prepare for paper all other rooms. Lath, plaister, flote, and set all partitions.

Ceilings.—Lath, plaster, flote, set, and whiten all ceilings.

Exterior Angles.—Form all exterior angles of chimney breasts or others in Keen's cement.

Cornices.—Run cornices of inches girt, enriched as per sketch* to all best rooms ; cornices of best bed rooms inches girt, and other bed rooms inches girt.

All cement work used to be of the best quality from approved makers, and mixed with the proper proportion of sand.

SLATER.

Roofs.—Cover the roofs with slates with proper lap upon ¾ inch slating battens, and two copper nails to each slate.

Ridge.—Provide and fix on the ridge ornamental (or plain) ridge tiles, as per sketch in margin, set in cement.

Slate Fittings.—(Here describe all slate fittings (if any) in pantry, or housemaid's closet, and if slate cistern, describe to contain gallons, 1½ inch bottom, and 1¼ inch sides, properly grooved and pointed, with red lead cement, and secured by iron bolts sheathed in lead piping.)

PLUMBER.

Water Supply, Cisterns, Piping.—Lay on water from the main in the road with 1¼ inch wrought iron welded pipes to the upper cistern (if any), and 1 inch ditto to the other cisterns. Put ball cocks to each, 1½ inch standing trumpet mouth waste, and perform other requisite plumber's work to make the cisterns complete. All bends, T's, and junctions are to be perfect, and to be hot turned; all cocks

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* Insert sketch in margin, if not given in detail drawings.

to be full way, and to be Lambert's patent for high pressure supply, and the whole of the pipes to be tested previous to their being covered up.

W. C.—Lay on water to each of the w. c.'s throughout by ¾ inch lead service pipe, put 4 inch lead branch soil pipe, D traps, 6 inch upright soil pipes into drain, and other requisite plumber's work to make the w. c.'s complete. 4lb. lead safes to closets above ground floor with small D traps and pipes into the traps of closets. Fit up the servants w. c. with common pan apparatus. Fit up w.c. on first floor with best approved valve apparatus with large oval basins.

Lavatory.—Put in washing lobby as shown on plan large blue earthenware basins to choice, lay on water by a ¾ inch lead branch service, put 1½ inch waste with ivory knob lever handle.

Housemaid's Sink.—Lay on water to housemaid's sink and butler's pantry with ¾ inch lead service, and 1½ inch waste and bell trap, and ¾ brass waycock.

Traps.—All wastes to be trapped before entering the drains.

Flats and Gutters.—Lay the whole of the flats and gutters with 6lb. lead, turning up 6 inches against the parapets, with 1½ inch drips, 1½ inch fall in 10 feet, and deep cesspools.

Trap in Roof.—Cover trap in roof with 6lb. lead projecting over trap 6 inches, and fastened with lead-headed nails.

Flashing.—Flash with 5lb. lead 9 inches wide, properly dressed and fastened with wall hooks, and stepped to the slopes of roofs to all chimneys and gables, dressed 5 inches upon the slating.

Rain Water Pipes.—Put No. stacks of 4 inch cast

iron rain water pipes, with cast heads to choice, from the eaves of roofs and carried into drains, properly fastened to walls.

Eaves Gutter.—Set to eaves cast iron eaves gutter moulded (or 4 in. half round) with joints set in red lead, and properly set upon cornice in cement (or fastened to ends of rafters).

Generally.—Provide all solder, lead-headed nails, wall hooks, hold fasts, and other materials of the kind, perform all labour in joints or otherwise for executing in the most workmanlike manner the whole of the plumber's work. Also provide all lead required by masons for joggling work or otherwise, for the smiths for running with lead the flanges of girders, and for any purpose required in the performance of work comprised in this specification. The lead to be properly milled pig lead, free from all defects.

GLAZIER.

Basement.—Glaze with ⅛ inch thick Hartley's patent the whole of the windows of basement and fixed sashes in ditto.

Fan Lights.—Glaze the fan lights in patterns in best seconds crown glass.

Bed Rooms.—Glaze the whole of the windows in bedrooms with best British plate in squares.

Remainder.—Glaze the remainder windows in best second crown glass in squares.

Generally.—Bed, brad, putty, and back putty all glazing, and use the best putty, clean all windows, repair damaged puttying or glazing, and leave all perfect at the completion and rendering up of the works.

Hartley's Glass.—Care to be taken that the Hartley's glass has the flutes upright and all one way, and picked evenly faced.

Fixed Sashes.—Glaze the fixed sashes in lobbies and w.c.'s with ground glass.

Ventilation.—Provide and fix a Moore's patent ventilator to each fixed sash in lobbies, pantry, &c.

PAINTER.

Use the best white lead and linseed oil, and perform the painter's work in the best manner, properly priming.

Exterior.—Paint four times in oil colour the whole of the external woodwork and ironwork usually painted.

Mahogany.—French polish to approval all the mahogany and oak work specified in joiner.

Interior.—Paint four times in oil colour to choice in plain tints the whole of the deal joiner's work and ironwork usually painted. The best rooms and best bed and dressing rooms to have an extra flatting coat.

Flatting.—Paint four times in oil, and flat the walls of hall and staircase.

Ceilings.—Properly prepare with size and finish in distemper the ceilings of best rooms, and whiten the remainder of ceilings.

Basement.—Colour in the best manner, strongly sized, the walls and soffits of the whole of the kitchens and offices (or basement) when not otherwise described.

Leave the whole of the painting and distempering and colouring clean and free from stains at the completion of the work.

SMITH.

Cast and Wrought Iron.—The cast iron to be of the best soft grey metal, to be cast free from blemish or other defects, and proved before being fixed. The wrought iron is to be of the best quality, well hammered or rolled, and free from flaws.

Provide and fix 1 inch wrought iron straps to each principal of roofs, and provide for partitions suspension rods, cwt. of wrought iron in bolts, and all proper nuts, plates, and screws.

Fit to basement (or kitchen and other windows without shutters) wrought iron framed guards, viz., $\frac{3}{4}$ inch. round iron 5 inches apart, with top and bottom wrought iron rail $1\frac{1}{4} \times \frac{1}{2}$ inch screwed to heads and sills of windows.

Provide for iron newels to staircases (or, if they be stone, then provide for iron ballusters and handrail as per design.)

Provide cast iron gratings to admit air under boarded floors as before described, also the several gratings required for the mouths of air flues.

Provide and set as specified in bricklayer.

(Here place in schedule the various rooms, and specify the amount to be provided for each range and stove, thus:—)

Kitchen Range . .	£	
Scullery do.	.	
Drawing and Dining Rooms	.	each.
Study	.	
Best Bed Room . .	.	each.
Other Bed Rooms . .	.	each.

The above prices to include fire brick backs.

Provide for bath and laying on cold water complete £

BELL HANGER.

The whole of the wires for the bell hanging to be composed of copper, with all necessary cranks, levers, pulls, and tubes for the concealed wires, the bells to be bright, of the best bell metal, of assorted tones, so as to be clearly distinguishable one from another.

Provide and hang the following bells, to be fixed upon a board and numbered with pendulum indication in the passage next kitchen, viz.:—from entrance, front and back; all rooms on ground floor, and all bed rooms and dressing rooms and bath room, a bell to ring in nursery from the best bed room, also a bell from kitchen to nursery.

PAPER HANGING.

(Describe the whole of the rooms and walls to be papered, and specify the amount per piece to be spent on each. The best papers will require to have first a coat of lining paper.)

It is most desirable that the paper hanging should not be done until at least six months have expired after the completion of the building; and, except in special cases, it is better not to include this work in the building contract; or, if this be done, to merely provide a sufficient sum which may be spent at the time, or deducted from the contract amount, if the work is not done by the contractor.

GENERAL CONDITIONS.

(TO BE ATTACHED TO A SPECIFICATION.)

THE contractor of in the county of in consideration of the sum of to be paid him by of in the county of the employer, his executors, administrators, and assigns, in the manner following: that is to say, that he, the said contractor, or his executors, administrators, and assigns, shall and will execute in a sound and workmanlike manner all and singular the several artificers' works required in building the shown in the drawings numbered 1 to inclusive, and signed herewith and according to this specification, and acording to such other instructions and drawings as may be furnished in writing by the architect; and also that he, the said contractor, or his executors and administrators, at his own or their own costs, shall and will provide all necessary labour, workmanship, materials, cartage, scaffolding, strutting, shoring, temporary enclosures and fences, and also all tools, tackle, cordage, rules, templates, models and moulds of every description, and all water for the use of

the works. And also that he, the said contractor, his executors or administrators, shall make good all cracks, fractures, or damages which may occur to the said premises, and which said reparations shall be and are hereby agreed to be considered as forming part of the said specification and description, and shall and will pay all fees to the District Surveyor, Sewers or Water Company, and will forthwith commence the works, and will deliver them up in a complete state, duly executed and finished to the satisfaction of the architect, on or before the day one thousand eight hundred and under a penalty of pounds per week for every week that the said works shall remain unfinished, and by way of liquidated damages.

And in case the said contractor is incapable, or shall neglect or refuse to completely finish the said works, then, in either of such cases, it shall be lawful for the said employer, his executors, administrators, and assigns, to employ other artificers, and to retain and deduct the amount so expended, and the cost and charge of so doing, from the contract money, hereinbefore mentioned. And further, the said contractor shall employ, provide, and keep one or more competent foreman or foremen to superintend the said works, and to remain constantly during the hours of work upon the premises; and if the said architect shall consider any of these foremen to be incompetent, or act improperly, it shall be in his power to dismiss him or them, and put others or other in his or their place, at such weekly payment as the said architect may think proper, which payment shall be paid and deducted out of any moneys which may be due to the contractor by virtue of these presents. And it is hereby agreed that should any material be brought upon the site for the purpose of being used in

the building which the said architect or the clerk of the works employed on the part of the employer shall consider improper for the purpose of being used in the building, or which the said architect or the clerk of the works employed on the part of the employer, shall consider improper for the purpose, then the said contractor shall remove the whole of it within 24 hours after receiving a written notice so to do, signed by the said architect, to be given to the foreman or other principal workman upon the works; and in default of so doing the said contractor shall pay the sum of £ by way of liquidated damages for every day that the said material remains on the site, and if the employer is put to the expense of removing the said material in consequence of the contractor refusing to do so, then he will be debited the cost and charges of so doing, as aforesaid. And it is further agreed that if the said employer shall think proper to make any alteration, addition, or omission to and in the said works herein contracted for, the said contractor, his executors, administrators, or assigns shall and will alter, add to, or omit accordingly, as the case may require, upon a written notice or direction specifying such alterations, signed by the said architect and delivered to the said contractor or his principal foreman; and further, that any such alteration shall not invalidate the contract, but the cost of any such works for which such notice in writing shall have been given shall be ascertained by valuation and measurement, in all respects according to the schedule which the contractor is required to send in with his tender, and shall be added to or deducted from the amount to be paid by the said employer, as the case may be. And, it is further provided that the contractor, his executors, administrators, or assigns, shall not, unless with the consent of the said architect, make any

such contracts for the execution of the said works; and neither the said architect nor the said clerk of the works shall be required to set out any of the works to be done, but the said contractor, his executors, administrators, or assigns, shall execute them from the copies of the said drawings, to be taken by the said contractor for his own use.

And in consideration of these premises the said employer, for himself, his heirs, executors, and administrators, doth hereby covenant and agree, with the said contractor, his executors, administrators, and assigns, that he, the said employer, shall, subject to the provisions herein contained, well and truly pay or cause to be paid to the said contractor, his executors, administrators, or assigns, the aforesaid sum of by instalments of 75 per cent. of the value of the work done and fixed in its place, and 50 per cent. of the value of materials delivered on the site. Provided always that the said contractor shall not be entitled to recover any such instalments until the same are certified to be done in writing by the said architect. And it is hereby covenanted and agreed by and between the said parties, that the said or other the architect for the time being of the said employer, his executors or administrators, shall be sole arbitrator between the said parties hereto, as to the quality of the materials, and soundness or nature or sufficiency of the works provided, done, and executed in pursuance of this contract; but should any dispute arise respecting the quality or value of any works which by reason of any written order shall be added, altered, or omitted, then the dispute shall be left to the determination and award of two indifferent persons as referees, one to be named by the contractor, and the other by or on the part of the said employer, and this award is to be taken as con-

clusive. In the further case of their not being able to agree to an award, then they shall choose an umpire, whose decision shall be final on all points to be brought before him. And, it is further agreed that such submission be made a Rule of one of her Majesty's Courts at Westminster at the option of one of the parties of the contract, and the umpire or referee shall award who will bear the expense of the said rule as aforesaid.

(Signature of Contractor.)

Witness

CONTRACT.

Agreement made this day of in the year of our Lord between in the county of of the one part, and of in the county of and hereinafter called the contractor, of the other part.

Whereas the said is desirous of building a at and has procured plans and specifications for the same from of architect, and the said has tendered to do and perform all the works contemplated in the said plan and specification at and for the sum of which tender the said hath agreed to accept on the said contractor entering into the agreements and accepting the conditions hereinafter made, and described in the General Conditions attached to the said specification :

Now it is hereby witnessed that he, the said contractor, for himself, his heirs, executors, administrators, and assigns, doth hereby agree that he will, at his own cost, execute all

the works of every kind required for carrying out all the works, shown and described on the said plans and specification, in the best and most workmanlike manner, and to the entire satisfaction of the said architect, and that he will accept the decision of the said architect in all points connected with the performance of the works and the quality of materials, as final and conclusive.

The whole of the works specified to be done to be commenced forthwith, and to be entirely finished and delivered up in a perfectly complete state on or before the day of in the year of our Lord ; on failure whereof, the contractor shall forfeit and pay to the said the sum of per week for every week that the works remain unfinished and undelivered up as aforesaid, which sum the said shall be empowered to deduct from any moneys due to the said contractor from the said as liquidated damages.

And in case the contractor is incapable or shall neglect or refuse to proceed with the work or to finish the same, in either of such cases it shall be lawful for the said his executors, administrators, and assigns, to employ other artificers, and to retain and deduct the amount so expended, and the cost and charges of so doing, from the contract money hereinbefore mentioned. And further, the said contractor shall employ, provide, and keep one or more competent foremen to superintend the said works, and to remain constantly during the hours of work upon the said premises; and if the said architect shall consider any of the foremen incompetent or to act improperly, it shall be in his power to dismiss them or him, and to put others or other in his or their place, at such weekly payment as the said architect may think proper; which payment shall be deducted and paid out of any moneys

which may be due to the contractor by virtue of these presents.

And it is hereby agreed that, should any materials be brought upon the site, which in the opinion of the said architect or his clerk of the works shall be considered improper to be used upon the works, the said contractor shall remove the same within 24 hours after receiving written notice to do so; and in default of so doing, the contractor shall pay the sum of for every day that the said materials remain upon the site; and if the employer is put to the expense of removing the said materials, the cost and charges of removing the same to be deducted from the moneys due and owing from the said employer to the said contractor.

And it is further agreed that no alterations or omissions in the work described to be done on the said drawings and specifications shall invalidate the contract, and the said contractor, his executors, administrators, or assigns, shall alter, add to, or omit any work or materials ordered to be added to or omitted, as may be directed by a written order signed by the said architect; and the cost of such additions or omissions to be added to or deducted from the contract money, according to a schedule of prices which is to be delivered by the said contractor and signed by him at the same time as this contract, and to be measured and the prices valued from the said schedule. All materials delivered on the site to become the property of the employer, but the contractor is to be responsible for all loss or damage that may occur to any materials, or damage to workmanship by malice, fire, storm, or other misadventure.

And in consideration of these premises, the said employer for himself, his heirs, executors, and administrators, doth

hereby covenant and agree with the said contractor, his executors, and administrators, that he, the said employer, shall, subject to the provisions herein contained, well and truly pay or cause to be paid to the said contractor, his executors or administrators, the aforesaid sum of by instalments at the rate of 75 per cent. of the value of the work done and fixed in its place, and per cent. of the value of work and materials brought upon the site; such payments to be made upon a written certificate from the said architect and within seven days after the certificate has been presented to the said employer by the contractor.

And it is further hereby covenanted and agreed by and between the said parties, that the said or other the architect for the time being of the said employer, his executors or administrators, shall be sole arbitrator between the said parties hereto as to the quality of the materials and soundness or nature and sufficiency of the works provided, done, and executed in pursuance of this contract; but should any dispute arise respecting the quantity or value of any works which by reason of any written order were added, altered, or omitted, then the dispute shall be left to the arbitration of two indifferent persons as referees, one to be named by the contractor and one by the employer, and their award is to be taken as conclusive. Or, in the further case of their not being able to agree to an award, then they shall choose an umpire, whose decision is to be final and binding on all points brought before him. And it is further agreed that such submission be made a rule of one of her Majesty's Courts at Westminster, at the option of one of the parties of the contract, and the umpire or referees shall award who shall bear the expense of the said rule as aforesaid. In witness

whereof the said parties have hereunto set their hands, the day and year first above written.

Witness to the signature of	*(Employer's signature.)*
Witness to the signature of	*(Contractor's signature.)*

FOUNDATIONS.

It is unnecessary that we should remark on the necessity of good foundations, the natural or the artificial; for where they are bad, we all know what fatal consequences may ensue.

Notwithstanding all that has been said to the contrary, we certainly have natural foundations, even if we have to sink or pile fifty feet deep to reach them; if we have to excavate eight or ten feet to reach a sound bed, that bed is the natural foundation.

Artificial foundations are constructed in the various earths, as clays, chalk, gravel, land, and on rock.

Foundations built upon the stratified or unstratified rocks, are generally easy and simple enough, more particularly those on the latter.

Getting in foundations, however, on some of the stratified rocks requires considerable attention; the rock may be more or less rotten, contain water, dip very much, or be full of pot holes; under such circumstances, though they do not fortunately occur very often, we shall have considerable sinking to do, a good deal of levelling to reach a solid steady surface, pot holes to clear out and make sound by means of concrete or masonry. We merely mention this for the student's attention, because it is considered by many, who have not had to treat rock work foundations, that the word rock invariably means a sound foundation.

Generally, however, with such natural foundations, there is but little excavation to do, as we have merely to cut down to the clean healthy rock, and this usually is done

by steps, or *benching*, according to the quality and inclination of the rock. If, however, we are building on the side of a hill, and the construction we have to raise is at all heavy, as for instance a mansion, a factory, a tall chimney, or the pier or abutment of a viaduct or bridge, the rock foundations will often necessitate a careful examination, or the new weight brought on to the ground may occasion a slip. Under such circumstances as the above, we shall find in some cases that considerable excavations have to be made to reach a solid bed, or a series of horizontal and sound beds of rock; where this occurs, the only consolation we can expect, is that much of the material excavated will be made useful, for in such situations there is often a total absence of gravel for making concrete, and the stone excavated will therefore come in very useful. Under similar circumstances, cases occur where the purchase, getting, and carting gravel would come more expensive than the purchase of stone.

Amongst the rock foundations we may place the building in chalk. This earth is sometimes as indurated and solid as stone; at others, from the presence of water, it is peculiarly soft, in which case almost the only remedy is to trench so as to lead the water off, and get in the artificial foundations below the water level; when this kind of thing occurs, instead of making a misfortune of it, we may often turn it to advantage, as we may very likely obtain a valuable well on the spot. If, however, this is not desirable, we may lead the water off; but if the spring or leak is at all considerable, the idea of building it up may be impossible, or very difficult, or more or less attended with danger, for we cannot foresee when heavy rains or the melting of heavy snows may cause it to break out again with very dangerous consequences.

Foundations in clays, loams, and gravels, may be classed together. Generally we shall have to sink into them to some depth; this will depend on the soundness of the beds we reach in excavating, and the weight of superstructure to be brought on to them, and sometimes their dip; they may be clean, homogeneous, and compact, or loose, coarse, and watery; in clay soils particularly, water is a most dangerous enemy, and very coarse black gravel is little better. In the latter, however, we can generally excavate and get in concrete; but in wet clay foundations, we must drain, and at any cost get rid of the water; for not only is it dangerous to substantial constructions, but will prove a perpetual source of damp and even disease in a building, both as regards the materials and the health of any future inhabitants. Clay foundations, indeed, always require particular attention on this subject, even when we find them dry and solid at the time of excavating, for it does occur that the mere sinking of the foundation pits, leads to the future advent of water, of which it is very difficult to get rid afterwards, when the proper means have not been adopted at first.

Gravel foundations should almost invariably be well grouted before the footings of the building are got in, as nothing tends better to consolidate the loose surface: in very many cases a foot of concrete over the full width of the trench is a very advantageous precaution, and it should be allowed to set, before the footings are got in.

In excavating foundation pits or trenches, it is worth while, for economy and for the sake of the work, to pay attention that the pits and trenches are excavated only to the necessary width and form. When the brick or stone is not of a hard substantial quality, it will be found a great improvement to fill in the trenches or pits with concrete by the side of the brickwork or masonry.

Dry, clean, cohesive sand often makes a good dry foundation, provided there be no possibility of its slipping or giving way laterally under the weight of the superstructure. But as soon as the condition obtains of any thing like quicksand, with the superadded possibility of moving, very great precaution is necessary. Water must be temporarily or permanently withdrawn if possible, or intercepted, often by close or even caulked sheet piling, and the quicksand must be either removed altogether, or safely confined by piling all round; it may often then be made the soundest of foundations; if the bed of sand be shallow, it *may* be cleared out altogether, the pit made clean down to the substratum, sheet piling got in on all sides, and the pit filled in with concrete or masonry. Before disturbing the sand, however, to any extent, the nature of the substratum should be ascertained, which may be generally done by sufficient boring.

If the sand be of any depth, or the substratum unfavourable, or if there be much water, then the probabilities are that we shall have to resort to piling, and if the pit be extensive, there will not be much time to lose, for it is sometimes difficult to say how soon the sides of the pit may come in, unless very extensively shored up and plank piled.

The piles to be driven, will either have to become so many columns or pillars, holding their footing solidly in the substratum, or they will have to be driven sufficiently numerous, so that their friction alone in the sand is sufficient to ensure their stability; in which case, of course, the sand will still have to be confined by piling all round, and the pit filled to a given height with a mass of concrete. It will not be a case of leading the water off, because the sand will come away with it; the condition to attain is to

restore the previous state of things, with the addition of a sufficiently stable seat to bear the superstructure.

Generally, under such circumstances it is preferable and more economical to pile right down into the solid sub-stratum, and to rely upon this only; but when the sand is of *very great* depth, this may come to be very expensive work.

The piles will be from 10 to 15 inches square, according to depth, and sometimes according to the timber we can obtain; pointed and shod with wrought iron shoes, weighing from 18 to 30 lbs., according to size of pile and the nature of the substratum they are to be driven into, and ringed at top to prevent their splitting.

When driven to a sufficient depth, the heads are cut off to the water level, and upon these the platform is got in.

MASONRY.

MATERIALS.

When it lies in the power of the architect or engineer to select materials according to his own choice and opinion, it will be found well worth while to make a careful study of the materials which a district is capable of supplying. This is a branch of *local information* which always adds largely to the value of practical experience. The knowledge thus acquired often enables the practical man to obtain economically some of the best or most applicable meterials of a district, and to use them advantageously in different portions of his buildings.

The different quarries are always good places to examine the character of different stones, which always show themselves on the weather worn faces, and the strata should be examined at different depths, as in the same quarries the materials often differ to a very considerable extent. The stone buildings of the district also require examination, both as regards the mouldings and the wall faces.

An equable structure in the grain of the material and a fair degree of hardness are generally indispensable qualifications; generally stone of unequal corformation, more particularly amongst the sandstones, are apt to scale from the effects of weather and to decompose; excessively hard stone is expensive to work with the chisel, but on the other hand where an artistic study of dressed and undressed materials can be introduced, it forms excellent walling. Great economy, and at the same time durability, are often to be effected by these means, as evinced by many mediæval

buildings. It is not uncommon to make a design first and study the material afterwards; but where there is nothing to prevent it, it would generally be advantageous to adopt the opposite course.

Amongst the stones chiefly used for engineering and architectural purposes we may enumerate,

Granites,
Sandstones,
Limestones, Magnesian Limestones, Oolites, &c.

Granite is one of the most intractable materials under the labour of the mason, though scarcely more so than some of the fine close-grained sandstones. Even in work of plain character, labour on granite is always expensive, as may be seen from the following average prices:

	Blue Aberdeen, Blue Peterhead, &c.		Penryn, Haytor, Dartmoor.	
Labour only, per foot superficial—	*s.*	*d.*	*s.*	*d.*
Plain work	1	8	1	6
In sunk work	2	0	1	10
Moulded work	4	0	4	0
Beds and Joints	0	10	0	10

The following tables exhibit the composition and qualities of various Sandstones and Limestones:—

SANDSTONES.

Composition.	Craigleith.	Darley Dale (Stancliff)	Heddon.	Kenton.	Mansfield.
Silica	98·3	96·40	95·1	93·1	49·4
Carbonate of Lime	1·1	·36	·8	·2	26·5
„ Magnesia					16·1
Iron, Alumina ...	·6	1·30	2·3	4·4	3·2
Bitumen					
Water and loss ...		1·94	1·8	·5	4·8

	Craig-leith.	Darley Dale (Stancliff)	Heddon.	Kenton.	Mans-field.
SPEC : GRAV :					
Of Particles	2·646	2·993	2·643	2·625	2·756
Of Dry Masses ...	2·232	2·628	2·229	2·247	2·338
ABSORBING POWERS	·143		·156	·143	·151
DISINTEGRATION.					
Quantity of matter disintegrated in grains	·6	·121	10·1	7·9	7·1
COHESIVE POWER.					
Crushing weight in cwts. on 2 inch cubes	280·8	253·	141·7	177·1	182·2

From the above it will be observed that the Mansfield contains only about half the proportion of silica as compared with the other specimens, and approaches much more nearly to the limestone; its specific gravity in particles and masses is also deserving of consideration as compared with its high absorbing power. Heddon has by far the highest absorbing power, the greatest quantity of matter disintegrated, and the lowest cohesive power.

Craigleith and Darley Dale have by far the least disintegrated matter, and the highest cohesive powers; they contain also the most silica. The Craigleith, which is the hardest, contains three times as much carbonate of lime as the Darley Dale; it contains also very much less foreign matter than any of the other specimens; it is almost the lowest as regards specific gravity, which appears here to be no evidence of the power of cohesion or durability; the quantity of disintegrated matter in the Craigleith is far greater than in the Darley Dale, the specific gravity of the particles of which stands very high; evidently its particles are very close. If this stone could be ascertained to be the most durable, though not the very hardest, it would seem that only a small portion of carbonate of lime is desirable

in sandstones; next to the Craigleith it contains the least quantity of foreign matter in its composition.

We must here observe, that it is very difficult to draw positive general conclusions from the above; the facts however must always be of the highest interest to the *observing* practical man.

MAGNESIAN LIMESTONES.

To judge from the table at page 112, The Magnesian Limestones have a lower power of disintegration; the ratios of disintegration and absorbing powers do not appear to have any connection as regards the cohesive powers of the different stones, which appear rather to be determined by the small difference between the specific gravities of the particles and dry masses; that, however, with the least absorbing power (the Bolsover) has the highest cohesive power; but there is a great difference in the strength of the Roche Abbey and Park Nook, although their absorbing powers, and the differences in specific gravities of particles and dry masses are almost identical. It is remarkable also that the hardest is the most liable to disintegration and that it contains no silica. The specimen with the least absorbing power, and the highest cohesive resistance contains the most silica, the least carbonate of lime, the most iron and alumina, and in the analysis shows the most water and loss. There is a certain proportion between the quantities of carbonate of magnesia and carbonate of lime which seems to constitute an element of strength.

The Oolites.—Two of these at least have very large powers of disintegration; that in which there exists the greatest difference in the specific gravities of the particles and

the dry masses is the softest as regards cohesive power under a crushing load, and it has the highest disintegrating power. It will also be observed that these *Oolites*, as compared with the Magnesian limestones, have something like cent. per cent. less cohesive power, are infinitely more liable to disintegration, and that there exists no equality whatever between the proportions of carbonate of lime and carbonate of Magnesia.

The Limestones.—Amongst these stones, the Chilmark, having the highest cohesive power, shows some ratio of proportion in the quantities of silica and carbonate of lime, and there is but a small difference between the specific gravities in the particles and in the masses; the absorbing power is very small, but the disintegration is comparatively high. With the exception of the quantity of silica in Chilmark, there is a great similarity in the constitution of the Oolites and the Limestones.

WORKMANSHIP.

Workmanship is quite as important as material in all good construction, and there can be no good building in the absence of either. We have in masonry four distinct kinds of workmanship in putting the stones together; namely, *Rubble, Random Rubble, Block in Course, and Ashlar.*

In Rubble Masonry the stones are not dressed. In ordinary Rubble Masonry, the work is brought up in courses, the depth of which depends to some extent on the thickness of the stone to be procured from the quarries. The stones should be laid in mortar and carefully fitted; face stones

must tail in or be bonded into the backing; for rubble walling, as many through stones as possible should be introduced; this also, to some extent, will depend on the materials to be procured. The work should be brought up in courses not exceeding fifteen inches in depth, or thereabouts, well flushed in mortar worked into every crevice until the whole is well filled in. The stones in the face work should be hacked square, and the joints carefully pointed. The backing should consist of flat bedded stones, as large as may be procured; they should be well fitted together, obtaining as much bond as possible, made solid in mortar, and brought up level with every course of face work; no scabbling should be wasted, but they should be packed into the mortar between the vertical joints of the work; this saves mortar and makes better work; the hammer should be freely used, but not so as to risk the breaking of any of the bedded stones. Walls built of rubble two or three feet thick require a good deal of attention in the bringing up, and according to their magnitude a proportional quantity of workmanship and hammer dressing and hacking must be introduced. Rubble takes a good deal of mortar and flushing, and the consequent settlement of the work must be provided for, more particularly where the walls are of any height. Good work may be procured without coursing, if proper attention be paid to the bringing up of the work, but there can be no good work, or anything of the kind without *bond*, *through stones*, and *fitting the work together*. The endless difficulties which the architect and engineer meet with in obtaining these requirements, continually render a severity necessary, which they would often gladly avoid.

Where the rubble is uncoursed, a tolerably level course should be introduced at about every two or three feet, depending a good deal upon the size of the stone used, and

the workmanship introduced into the work, and this course should be thoroughly well grouted.

In random rubble, the stones are often used to some extent as blasted from the quarry; where the work is well fitted, when there are sufficient large stones introduced, well filled in with smaller ones, very good work may be produced with sufficient thickness of walling, and the work well filled in; bond is equally attainable here as in the former work, if some attempt be made to obtain it.

Backing may be of rubble stonework or brickwork, and even concrete, when well made and properly used, answers the purpose very well; when made with dry broken bricks instead of gravel, it is very light, at least as compared with ordinary concrete; the backing should be brought up at the same time as the face work, and the whole always bonded in together. The perfect settlement of the interior mass is the more important, since, from the smaller size of the stones and the rougher work, a greater shrinking will here occur than in the face work. Indeed, unless considerable care be exercised in this respect, the defect will eventually occasion the whole superincumbent weight to be thrust on the face work, and thus produce a bulging out, and probably a rupture of the face work. When the interior as well as the exterior face of a wall, or similar construction, is prepared with a fair face either of stone or brickwork, the interior is, for the sake of economy, occasionally filled in with rubble or other rough work, called hearting. Bonding, grouting, levelling, and consolidation are to be rigorously insisted upon in this mode of construction. Otherwise, if the stone facings are allowed to be too thin, too nearly of equal thickness throughout, or not thoroughly tailed into the interior mass, they will act as mere slabs or coatings, and be very liable to separation and

rupture. The levelling of each course of face work, must also be particularly attended to; and bond or through stones, fairly and solidly bedded, well fitted, and of sufficient size, must be abundantly provided.

KENTISH RAGSTONE.—This very old style of masonry has of late years been advantageously introduced into modern buildings of mediæval style of architecture. Combined with stone dressings, it forms both a picturesque and economical style of masonry. For ragstone ashlar work, the stone, when quarried, has its rough projections knocked off with a heavy double pointed hammer, such as we use for working granite. This operation is locally called "skiffling," and is the same as that which is known in the neighbourhood of London and other parts of the country by the term "*knobbling*." It is afterwards dressed with the hammer, with more or less care, according to the purpose for which it is required, when it is termed either "rough picked," or "close picked." Ragstone is also employed in the various forms of "coursed header work;" "random coursed work," in which the work is levelled in a coarse way at about every eighteen inches in height; "random header work," in which the headers are of all varieties of size; "random work," executed with unsquared stones, with the joints however fitted and pinned in with smaller stones; "rough random work," in which the stones are without dressing, but laid together as compactly as their irregular forms will allow, and the interstices filled in with small stones, or gallets, or scabblings.

BOND.—In the above remarks on rubble masonry generally, sufficient has been said to explain the value of bond in all works of masonry. In block, in course work,

and in ashlar, it is, if possible, more imperative still; it is indeed by this means that a mass of masonry is made solid. Hence the introduction of headers and stretchers.

Headers are stones which present their smaller ends in the face of the wall, their lengths running crossways in the wall; stretchers run longitudinally along the length of the wall, and the two dovetail or lock into each other. In piers of bridges, and in all walls generally which are not of very great thickness, a certain proportion of the headers should be through stones, that is, go right across the wall.

No two joints must be allowed to come over each other, and in fixing the minimum distance between the joints, regard must be had to the kind of construction intended, and also to the practicable or convenient sizes in which the blocks are to be procured. The width of each header deducted from its length, or the length of a stretcher, will leave the dimensions which, divided into equal parts, will give the distance which will occur between any one vertical joint and the nearest vertical joints in the courses above and below it. If, for example, the least length of stretcher be fixed at two feet nine inches, and the width on the face of the header at one foot three inches, we shall have nine inches for the allowed distance of joints.

If it is not desirable that the joints of the alternate courses should be exactly over each other, a little latitude should be allowed in the size of the blocks, which will not only enable us to have a wider selection from the beds in the quarry, but will often reduce the cost of material, inasmuch as it will enable us to receive blocks which would otherwise have to be rejected; it will also make a manifest saving in the cost of conversion by preventing waste of material. Thus an allowed distance of nine inches may be reduced to seven or eight inches

Similarly it will be evident that, as regards the stretchers, a like latitude may be advantageously allowed as regards their length, with advantage to the work and benefit to the contractor; always provided, of course, that discretion be used in the subject; thus, in a wall three feet thick, the length of the blocks, not through stones, may range from say one foot three inches to one foot nine inches.

In all good wrought masonry the beds and joints must all be parallel. Cubes of uniform size cannot be applied in bonded masonry. The two horizontal surfaces are termed the top and bottom beds; of the vertical joints one is "the face," and the other "the back," the other two being the side joints, or simply "the joints." The back is the joint which workmen are most prone to slight.

ASHLAR MASONRY. — The term Ashlar masonry is generally applied to stone work of large dimensions, and usually where the depth of the courses exceeds twelve inches. The stone must be of approved quality; according to the thickness of the wall, the lengths, widths, and depths of the stones must be specified. The stones must be laid alternately headers and stretchers. No ashlar masonry should break joint less than seven inches, and in specifying this, attention must be paid to the observations made above. All the joints must be truly dressed and in parallel courses. It will be necessary to specify whether beds and joints are to be dressed with the pick or with the chisel, or whether they are to be "rubbed," the latter of course being reserved for highly finished work. In almost all cases of ashlar dressing it is advisable to run a margin draft about one inch wide along the beds, as it very much tends to prevent flushing the edges of the stone, and it may be made as shallow as we please. The dressing of the face of the

stones must also be specified, as whether to be left quarry faced with a margin draft, or whether the edges are to be chamfered, that is, dressed off at an angle of 45°, or to be pick dressed or fair tooled. The angle formed by two faces of masonry is termed the arris, and it is to be particularly attended to, in the bringing up, that this be out of winding, that is, perfectly straight. All the face stones for battering work should be worked with a proper bevel on the face of the stone; the joints and beds must fit close, and underpinning is not to be allowed on any account; nothing is more likely to produce flushing of the edges of the stone, and even more serious evils. Grout nicks must, where required, be cut two inches deep and two inches wide in the side joints, corresponding with each other, so as to insure a solid dowel being made by running in pure cement until it overflows. Mortar of the best quality must be used, made with hydraulic lime and finer sand than in ordinary mortar, or cement.

Where ashlar is backed up by any other style of masonry, as "Bastard Ashlar work," as it is sometimes termed, the backing may be of unwrought stone, but of the same depth as the ashlar courses, with the joints all square and beds level, being pick-dressed. The whole must set flush in mortar, well bonded together. No joints in the backing will on any account be allowed to exceed half an inch, and these must be well grouted.

Where quoins are introduced, the size of the stones, the dressing of the faces, and joints must be specially specified.

In all cases of arches, the beds and joints of the arch stones must be accurately hammered and truly dressed, and the joints in the direction of the radius of the arch. The description of work in the face of the arch stones must also be specified, as, for instance, whether the arch quoins shall

have their faces and intrados fair tooled, or punched, or left quarry-faced with a margin draft, or whether the joints are to be chamfered.

For all skew arches, the courses must be laid spirally at right angles to the face of the arch.

Stones in the spandrils must be cut so as to fit the extrados of the arch.

The laggings of all centrings must be adzed when requisite, to procure a true and uniform curve.

BLOCK IN COURSE.—For this description of masonry, stone of a smaller size is used than for ashlar work. The depth of the courses in block in course varies from about eleven inches down to seven or eight inches, generally according to the size of the stone to be procured most economically. Proportionately to the depth, the length and width of the stones must be specified, and they should be of uniform depth throughout each course; they must be alternately laid as headers and stretchers. One fourth of the length of each course should consist of stones not less than thirty inches long, (or they should be through stones, and stretch across the full width of the wall,) laid as nearly equidistant as possible, and so as to effect a perfect bond with the rubble backing or hearting; the length of headers generally will vary from twenty to thirty inches, according to the depth of the courses. When there is necessity for deeper courses of block in course than those implied above, the length of the bond stones must be increased.

The beds and joints must be carefully hammer-dressed throughout, true and square, and they must be pick-dressed for at least nine inches from the face. The whole to be laid in mortar. The rubble backing to be described, if any, for which see what has been said above.

Where a wall or a pier is to be built of block in course throughout, all the joints and the beds should be pick-dressed from end to end and all over, and no packing or filling should be allowed.

In all block in course face work, where, from the manner in which the stones have been obtained in the quarry, some of them are broader at one end than at the other, one third at the least of all such stones should be dressed and set in such manner that the larger end will form the back of such stone, and be set in the inside or at the back of the work.

PREPARATION OF BLOCKS OF STONE.—Although the simple operation of preparing blocks of stone for building purposes may be very readily performed with the most simple tools, it is only by the application of the elementary rules of geometry that the more intricate and curvilinear forms of masonry can be accurately set out, and worked true and without waste of material. The square and straight edge will enable a mason to reduce his blocks to level faces, and to render these parallel or rectangular, or even bring them to certain oblique angles, but they will not enable him to strike curves, to determine the intersecting points of different plane or curved surfaces, or to determine the alterations produced in irregular figures in their conversion to figures of a different form. For these, and indeed for nearly all the problems he will be required to solve in working out the details of stone work, the workman must refer to the rules of practical geometry, and he will generally find all his operations facilitated in proportion to his knowledge of those rules.

For measuring and laying down angles, the level is used; this consists merely of two legs jointed like a foot rule,

but so that one leg may pass freely over the other, and with this any angle may be measured on a drawing and laid down; the bevel should be provided with a graduated arc and a clamp screw, and the joint of the legs should move rather stiffly than otherwise; arcs of circles are described with compasses, and elliptic curves are usually set out with the trammel. This simply consists of two pieces of wood fixed together at right angles and crossing each other. There are slits cut nearly throughout the whole length, in which two pins or studs attached to a separate piece of wood may be moved along, and these studs are capable of adjustment on the piece to which they belong. A pencil or pointer at the other end will describe ellipses, of which the major and minor axes will depend on the position of the studs. Besides the square for setting out right angles of two or three feet length of legs, the long square or level is for trying long lines. This is supplied with a plumb-bob hanging by a string, which indicates when the upright part is truly vertical; the long frame which is set accurately at right angles by the maker, is thus therefore truly horizontal or level; a spirit level is sometimes added to this instrument, but we prefer generally depending on the plumb-bob, which is not liable to get out of order. In setting out or bringing up work the plumb-bob should be freely used to test the straight line which the arrises of masonry should make. Particular forms of curved lines or intersecting planes, curved or mixtilinear, may be described upon ring plates, and then cut to the true shape, and can then be accurately multiplied as much as we please. Zinc is the usual material of which these templates are made, but stiff and coarse brown paper will answer the purpose for any mouldings that are not to be

very much repeated. The whole effect of the work will depend upon the accuracy with which the forms of these templates are cut, and great care should be taken in pricking off from the full size contour of mouldings on the drawing, as it very frequently happens that, after the architect has spent much care and anxious thought upon his moulding, the work is entirely spoilt in appearance from this not being properly attended to.

SANDSTONES OF GREAT BRITAIN.

The following table, compiled from the report of the Commissioners appointed to examine stones for the new Houses of Parliament, shows, 1st, the names of the principal sandstone quarries in Great Britain; 2nd, the county in which situate; 3rd, the weight per cubic foot of the stone in its ordinary state; 4th, the size of the blocks in which the stone can be procured; 5th, the price per cubic foot at the quarry; and 6th, buildings in which each stone has been employed. We thus present our young practitioner with a guide which will afford him most valuable and authentic information respecting all the principal sandstone districts in the kingdom.

No	Name of Quarry.	County.	Weight per Cubic Foot. lbs. oz.	Size of Blocks.	Price per Cubic Foot.	Buildings in which used.
1	Abercarne & Newbridge.	Monmouthshr.	167.15	1 to 10 tons.	4½d., or 5s. per ton.	Churches, &c., New Docks, at Newport and Cardiff.
2	Auchray	Forfarshire.	158.14	4 to 5 tons.	9d. to 1s. 5d. according to size.	In the Town and vicinity.
3	Ball Cross	Derbyshire.	. . .	. . .	. . .	At Chatsworth, and Bakewell.
4	Barbadoes	Monmouthshr.	146.12	1 to 10 tons.	10d. to 1s.	Tintern Abbey.
5	Bevis's Quarry.	Wiltshire.	111.2	6 to 7 ft. long	1s. 6d.	Salisbury, Hindon, &c., Bridges, Churches, &c.
6	Binnie.	Linlithgowshir.	140.1	. . .	1s. 1d. for comn. blocks 1s. 10d. to 2s., blocks from 12 to 14 ft.	New Club House, Edinburgh, New Bank, Greenock, &c., &c.
7	Bolton's Quarry.	Yorkshire.	126.11	100 feet.	10d. to 1s.	Whitby Abbey, Scarboro' and Bridlington Piers, Sheerness, and St. Katherine's Docks, &c.
8	Bramley Fall.	Yorkshire.	142.3	Tô 18 tons.	. . .	Bridges, Waterworks, &c.
9	Calverley.	Kent.	118.1	80 to 500 ft.	4d. to 6d.	Buildings at Tunbridge Wells.
10	Cat. Cralg.	Linlithgowshir.	141.11	Large size.	. . .	Sea Dykes.
11	Craigleith.	Edinburghsh.	145.14	Any length & brdth, & from 6in. to 10ft. thick	9d. to 2s. 6d.	Public Buildings at Edinburgh. Repairs of Blackfriars-bridge.

SANDSTONES OF GREAT BRITAIN.—(*Continued.*)

No	Name of Quarry.	County.	Weight per Cuoic Foot. lbs. oz.	Size of Blocks.	Price per Cubic Foot.	Buildings in which used.
12	Crawbank.	Linlithgowshir.	129.2	From 4 × 5 × 8ft. to 5 × 6 × 10ft.	1s. not above 5 cubic feet.	Roman Bridge, A.D. 140, Old Church, &c.
13	Duffield Bank.	Derbyshire.	132.14	150 feet.	9d. to 3 tons.	St. Mary's Bridge, &c., at Derby, Grammar School, Birmingham.
14	Gatherley Moor.	Yorkshire.	135.13	1 to 3 tons.	8d.	Aste Hall, Richmond, and Caterick Bridges, &c.
15	Gatton.	Surrey.	103.1	35 to 60 cubic feet.	1s. 4d. to 1s. 6d.	Hampton Court, Windsor Castle
16	Glammiss.	Forfarshire.	161.2	Any size.	7d. to 1s.	Glammiss Castle, &c.
17	Heddon.	Northumbrlnd.	130.11	Do.	6d. to 10d.	Church at Heddon, Monument, &c., at Newcastle.
18	Hollington.	Staffordshire.	133.1	30 to 40ft. square and 8ft. thick.	7d. to 1s.	Trentham Hall, Drayton Manor, &c. &c.
19	Humbie.	Linlithgowshir.	White, 140.3 Grey, 135.13	90 cubic feet and upwards.	Grey, 1s., White, 1s. 2d. to 1s. 10d.	Dundas Castle, Public Buildings in Edinburgh, Glasgow, &c.
20	Kenton.	Northumbrlnd.	145.1	10 tons.	6d. to 1s. 4d.	Nearly all new Bldgs. at Newcastl
21	Knockley, &c.	Gloucestershre.	159.5	To 50 feet.	1s. to 1s. 4d.	Cardiff New Pier, &c.
22	Lindley's Red Qurry.	Nottinghmshir.	148.10	To 10 tons.	8d. random.	Belton House.
23	„ White Quarry	Do.	149.9	Do.	8d. random.	Town Hall, Mansfield, &c.
24	Loch.	Forfarshire.	159 3	2 to 6 tons.	9d. to 1s. 5d.	Public Buildings in neighbourhd.
25	Lochee.	Do.	158.11	To 5 tons.	9d. and upwards.	Principal Buildings in vicinity.
26	Longannet.	Perthshire.	131.11	Do.	8d. to 2s. 6d.	Stadt House, Amsterdam, Exchange, Edinburgh, &c.
27	Morley Moor.	Derbyshire.	130 8	. . .	10d.	Bank at Derby, &c., &c.
28	Munlochy.	Rossshire.	160.9	Large size.	5d. to 5½.	Cathedral, Fortrose, A.D., 1124, Canal Locks, &c.

SANDSTONES OF GREAT BRITAIN.—(*Continued*).

No	Name of Quarry.	County.	Weight per Cubic Foot. lbs. oz.	Size of Blocks.	Price per Cubic Foot.	Buildings in which used.
29	Mylnefield, or Ring-oodie.	Perthshire.	160.0	Any size.	9d. to 1s. 5d.	Old Steeple, Docks, &c., Dundee, Bell Rock Lighthouse, &c.
30	Osmotherley.	Yorkshire.	. . .	. . . .	4d.	Village of Osmotherly.
31	Park Quarry.	Do.	. . .	27 feet cubic.	. . . .	Castle Howard.
32	Park Quarry.	Staffordshire.	124.9	15ft. or more, by 3 to 6 feet.	8d., selected.	Triumphal Arch, &c., Tixall; Church, &c., at Birmingham.
33	Park Spring.	Yorkshire.	151.1	Any size 3 feet thick.	9d. to 2 ton blocks.	Commercial Buildings, Leeds.
34	Pensher.	Durham.	134.5	Any size.	8¾d.	Sunderland Pier, Seaham Harbour, Victoria Bridge on Wear.
35	President.	Dumbartonshr.	. . .	Do.	1s. 6d., from 16 to 20 cubic feet.	Bank of Scotland, Glasgow, &c.
36	Pyotdikes.	Forfarshire.	162.8	To 7 tons.	10d. to 1s. 2d.	Dundee Harbour.
37	Scotgatehead	Yorkshire.	158.0	. . . .	8d.	York Castle, &c.
38	Shaw Lane.	Derbyshire.	135.15	150 cubic feet.	9d. to 1s. 1d.	Leicester Church.
39	Stancliffor Darley Dl.	Do.	148.3	Very large size.	1s. 5d. to 5 tons.	Abbey, Darley Dale, Bldgs. Birm.
40	Stanley.	Shropshire.	146.0–141.7	10 to 70 feet.	1s. to 2s. 3d.	Stourport, Worcester, & Bewdley, and Gloucester Bridges, &c.
41	Stenton.	Durham.	142.8	15 to 20 feet long.	5½d. small blocks.	Barnard Castle, &c.
42	Talacre & Gweslyr.	Flintshire.	150.4	15 tons.	1s. to 1s. 3d.	Denbigh & Rhuddlan Castles, &c.
43	Victoria.	Yorkshire.	145.3	120 cubic feet.	1s.	Catholic Church, Leeds.
44	Viney Hall.	Gloucestershre	155.11	. . . .	11d. for red rock.	Cardiff New Pier, &c.
45	Warwick.	Yorkshire.	148.10	12 to 20 feet long, 5 to 7 feet wide.	8½d.	Public Buildings in Manchester, &c.
46	Wheatwood.	Do.	143 0	Any size.	9d. to 1s. 6d.	Church at Leeds, Grand Junction Canal, London & Croydon Rail.
47	Whitby Co's., Aislaby.	Do.	126.11	40 by 25 feet.	10d. random blocks, 60 to 200 feet.	Whitby Abbey, Cemetery, Highgate, Hungerford Market, &c.

QUALITIES OF SANDSTONES.

The following table will exhibit the chemical constitution of five specimens of sandstone; also the specific gravity; the absorbing power or disposition to imbibe water; the liability to disintegration; and the cohesive power of each variety. To try the absorbing powers, the specimens were saturated under the exhausted receiver of the air-pump.

	Craig-leith.	Darley Dale, (Stan-cliff.)	Heddon.	Kenton.	Mans-field, or C. Lind-ley's Red
Analyses.					
Silica	98.3	96.40	95.1	93.1	49.4
Carbonate of Lime . .	1.1	0.36	0.8	2 0	26.5
Carbonate of Magnesia . .	0.0	0.0	0.0	0.0	16.1
Iron Alumina . . .	·0.6	1.30	2.3	4.4	3.2
Water and loss . . .	0.0	1.94	1.8	0.5	4.8
Bitumen . . .	0.0	0.0	0.0	0.0	0.0
Specific Gravities.					
Of particles . . .	2.646	2.993	2.643	2.625	2.756
Of dry masses . .	2.232	2 628	2.229	2.247	2.338
Difference. . . .	414	365	414	378	418
Absorbent Powers . .	0.143	- - -	0.156	0.143	0 151
Disintegration.					
Quantity of matter disintegrated in grains . . .	0.6	0.121	10.1	7.9	7.1
Cohesive Powers.					
Crushing weight in cwts., cubes of 2 inch sides . .	280.83	253.00	141.68	177.10	182.16

These results are worthy our entire confidence, having been obtained by that eminent chemist and analyst, the late Professor Daniell, aided by Professor Wheatstone. Although it is difficult to deduce general conclusions from these experiments, yet the particular facts recorded are of the highest practical importance.

The following table, compiled from the same authority as that of sandstones, will be found to contain similar particulars of each kind of stone.

LIMESTONES OF GREAT BRITAIN.

(Including the ***Magnesian***, the ***Shelly***, and the ***Oolite***, as indicated by the letters M, S, and O, respectively following the number in the first column.)

No.	Name of Quarry.	County.	Weight per Cubic Foot. lbs. oz.	Size of Blocks.	Price per Cubic Foot	Buildings in which used.
1. O	Ancaster	Lincolnshire	139.4	3 to 5 tons	9d. in random blocks	Wollaton Hall, Belvoir Castle, &c.
2. O&S	Barnack Mill	Northamptnsh.	136.12	To 30 feet	1s.	Burleigh House, Peterborough Cathedral, most Churches in Lincolnshire, and Cambridgeshire, &c.
3. O	Bath (Lodge Hill)	Somersetshire	116.0	12 to 96 cubic feet	6d.	Kennet and Avon, and other Canals, restoration of Henry VII. Chapel, 32 years ago.
4. O	Bath (Baynton Quarry)	Wiltshire	123.0	To 10 tons	7d.	Laycock Abbey, Windsor Castle, &c.
5. O	Bath (Drewe's Quarry)	Do.	122.10	To 125 feet	6d.	Buckingham New Palace, St. James's Square, Bath.
6. M	Bolsover	Derbyshire	151.11	56 feet	10d.	Southwell Church, &c.
7. M	Brodsworth	Yorkshire	133.10	. . .	. . .	Doncaster Old Church, &c.
8. M	Cadeby	Do.	126.9	. . .	. . .	Day and Martin's, High Holborn, Almshouses at Edgeware.

LIMESTONES OF GREAT BRITAIN.—(*Continued.*)

No.	Name of Quarry.	County.	Weight per Cubic Foot. lbs. oz.	Size of Blocks.	Price per Cubic Foot	Buildings in which used.
9.	Chilmark*	Wiltshire	153.7	To 5 tons	1s. 6d. to 2s.	Salisbury Cathedral, Wilton Abbey, &c.
10.S&O	Cranmore	Do.	134.4	Large size	7d.	Cathedral of Wells, &c.
11. S	Hamhill	Somersetshire	141 12	. . .	1s. 4d.	Buildings in vicinity.
12. O	Haydor	Lincolnshire	133.7	14 feet × 3 ft. × 4ft.	8d.	Lincoln Cathedral, &c.
13.	Hopton Wood	Derbyshire	158.7	100 cubic feet	3s. to 4s.	Chatsworth, Belvoir Castle, &c., &c.
14. M	Huddlestone	Yorkshire	137.13	To 250 cubic feet	2s.	York Minster, Selby Cathedral, &c.
15. O	Ketton	Rutlandshire	128.5	To 100 feet	1s. 9d.	Buildings in Cambridge, &c., St. Dunstan's Church, Fleet-street, London.
16 M	Park Nook	Yorkshire	137.3	Any size	7d.	Pontefract Old Church.
17. O	Portland, Vern Street Quarry	Dorsetshire	134 10	Do.	1s. 4½d.	Public Buildings in London.
18. O	Portland, Waycroft Quarries	Do.	135.8	Do.	1s. 4½d.	Goldsmith's Hall, Reform Club House and other Buildings in London.
19. O	Portland, Gosling's Quarry	Do.	126.13	Do.	1s. 4½d.	Public Buildings in London.

* This Limestone is described as being "Siliciferous," that is, containing a moderate proportion of silica, and occasional grains of silicate of iron.

LIMESTONES OF GREAT BRITAIN.—(*Continued*).

No.	Name of Quarry.	County.	Weight per Cubic Foot. lbs. oz.	Size of Blocks.	Price per Cubic Foot	Buildings in which used.
20. O	Portland, Grove Quarry Bowers	Do.	145.9 to 147.10	Do.	1s. 4½d.	St. Paul's Cathedral, and other Buildings during the reign of Queen Anne.
21. M	Roche Abbey	Yorkshire	139.2	To 10 tons	8d. to 1s 6d.	Roche Abbey Church, Selby Hall, &c.
22.	Seacombe	Dorsetshire	151.0	From 6 ft.×2 ft.×3ft. to 8 ft.×3 ft.×4 ft.	1s. 2½d.	Lighthouse at Margate, West India Docks, &c.
3. M	Smawse	Yorkshire	127.8	8 ft. × 3 ft. × 3 ft.	7d.	Hull Old Church, Ripon Minster, &c.
24.O&S	Taynton or Teynton	Oxfordshire	135 15	Any size	10d. to 1s.	Blenheim, interior of St. Paul's, and other Churches in London, &c.
25.	Totternhoe*	Bedfordshire	116.8	40 cubic feet and upwards	1s. 3d.	Dunstable Priory Church, Woburn Abbey, &c.
26. O	Windrush	Gloucestershire	118.2 to 135.15	5 to 40 feet	8d.	Windrush Church, and Buildings in neighbourhood.

* This stone is argillaceous, consisting of calcareous and argillaceous matter in about equal proportions.

The Table which follows exhibits the chemical constitution of eleven specimens of the Limestone class, viz., 4 Magnesian Limestones, 4 Oolites, and 3 Limestones. It also shews the specific gravity; the absorbing power, or disposition to imbibe water; the liability to disintegration; and the cohesive power of each specimen The absorption was tested by saturating the stones under an exhausted receiver.

QUALITIES OF LIMESTONES.

	Magnesian Limestones.				Oolites.				Limestones.		
	Bolsover.	Huddlestone.	Roche Abbey.	Park Nook.	Ancaster.	Bath Box.	Portland.	Ketton.	Barnack.	Chilmark.	Ham Hill.
Analyses.											
Silica	3.6	2.53	0 8	0.0	0.0	0.0	1.20	0.0	0.0	10.4	4.7
Carbonate of Lime	51.1	54 19	57.5	55.7	93.59	94.52	95.16	92.17	93.4	79 0	79.3
Carbonate of Magnesia	40.2	41.37	39.4	4 .6	2 90	2.50	1.20	4.10	3.8	3.7	5.2
Iron Alumina	1.8	0 30	0.7	0.4	0.80	1.20	0.50	0.90	1.3	2.0	8 3
Water and loss	3.3	1.61	1.6	2.3	2.71	1.78	1.94	2.83	1.5	4.2	2.5
Bitumen	0.0	0.0	0 0	0.0	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.
Specific Gravities.											
Of particles	2.833	2.867	2.840	2.847	2.687	2.675	2.702	2.706	2.627	2.621	2.695
Of dry masses	2.316	2.147	2.134	2.138	2.182	1.839	2,145	2.045	2 090	2.481	2.260
Difference.	517	720	706	709	505	836	557	661	537	140	435
Absorbent Powers	0.182	0.239	0.248	0.249	0.180	0 312	0.206	0.244	0.204	0.053	0.147
Disintegration in grains	1.5	1.9	0.6	1.8	7.1	10,0	2.7	3.3	16.6	9.8	9.5
Cohesive Powers.											
Crushing weight in cwts., cubes of 2 inch sides	296.01	154.33	139 15	154.33	83.49	53 13	75.90	91.08	63.25	255.53	

The results here exhibited are of great practical importance.

A TABLE

Showing the weight of 1 foot of Flat bar iron, from 1 inch broad and ⅛ of an inch thick to 4 inches broad and 1 inch thick, close hammered, in parts of an inch in thickness.

Breadth.	⅛		¼		⅜		½		⅝		¾		⅞		1 in.	
In	lbs.	oz.	lbs.	oz.	lbs.	oz.	lbs.	oz.	lbs.	oz.	lbs.	oz.	lbs.	oz.	lbs.	oz.
1	0	6⅞	0	13¾	1	4⅝	1	11½	2	2⅜	2	9¼	3	0⅛	3	7
1⅛	0	7¾	0	15½	1	7¼	1	15	2	6¾	2	14½	3	6⅛	3	13⅞
1¼	0	8⅝	1	1¼	1	9¾	2	2⅝	2	10⅞	3	3⅝	3	12⅛	4	4¾
1⅜	0	9½	1	3	1	12⅜	2	5⅞	2	15¼	3	8¾	4	2⅛	4	11⅝
1½	0	10⅜	1	4⅝	1	15	2	9¼	3	3½	3	13⅞	4	8⅛	5	2½
1⅝	0	11⅛	1	6⅜	2	1½	2	12⅝	3	7⅞	4	3	4	14¼	5	9⅜
1¾	0	12	1	8	2	4	3	0⅛	3	12⅛	4	8⅛	5	4¼	6	0¼
1⅞	0	12⅞	1	9¾	2	6⅝	3	3½	4	0½	4	13⅜	5	10¼	6	7⅛
2	0	13¾	1	11½	2	9¼	3	7	4	4¾	5	2½	6	0¼	6	14
2⅛	0	14⅝	1	13¼	2	11⅞	3	10⅛	4	9	5	7⅝	6	6¼	7	4⅞
2¼	0	15½	1	15	2	14⅜	3	13⅞	4	13⅜	5	12⅞	6	12¼	7	11¾
2⅜	1	0⅜	2	0⅝	3	1	4	1⅜	5	1⅝	6	2	7	2⅜	8	2⅝
2½	1	1⅛	2	2⅜	3	3½	4	4¾	5	6	6	7⅛	7	8¾	8	9½
2⅝	1	2	2	4	3	6⅛	4	8¼	5	10¼	6	12¼	7	14⅜	9	7⅜
2¾	1	2⅞	2	5⅞	3	8¾	4	11⅝	5	14½	7	1½	8	4⅜	9	7¼
2⅞	1	3¾	2	7½	3	11⅜	4	15	6	2⅞	7	6⅝	8	10⅜	9	14⅛
3	1	4⅝	2	9¼	3	13⅞	5	2½	6	7⅛	7	11¾	9	0⅜	10	5
3⅛	1	5½	2	11	4	0½	5	6	6	11¾	8	0⅞	9	6⅜	10	11⅞
3¼	1	6⅜	2	12⅝	4	3	5	9¾	6	15¾	8	6	9	12⅞	11	2¾
3⅜	1	7¼	2	14½	4	5⅝	5	12⅞	7	4	8	11¼	10	2½	11	9⅝
3½	1	8	3	0⅛	4	8⅛	6	0¼	7	8¼	9	0⅝	10	8½	12	0½
3⅝	1	9	3	1⅞	4	10¾	6	3⅝	7	12⅝	9	5⅛	10	14½	12	7⅜
2¾	1	9¾	3	3½	4	13¾	6	7⅛	8	1	9	10⅝	11	4½	12	14¼
3⅞	1	10⅝	3	5¼	5	0	6	10½	8	5¼	9	15⅞	11	10½	13	5⅛
4	1	11½	3	7	5	2½	6	14	8	9½	10	5	12	0½	13	12
12	5	2½	10	5	15	7½	20	10	25	12½	30	15	36	1½	41	4

Cast Iron according to same thickness.

12	4	13⅜	9	10⅝	4	8	19	5⅜	24	2¾	29	0	33	13⅜	38	10¾

CULVERTS. BARREL DRAINS, AND WELLS.

Showing what quantity of Brickwork is contained in any Culvert, from 9 inches in diameter and 4½ inches thick, to 6 feet in diameter and 18 inches thick, and the number of Bricks required for, and the Cubic feet contained in, 1 lineal yard.

Diameter Clear.		Thickness of Rim.		1½ Brickwork in 1 lineal yard.		No. of Bricks to lineal yard.	Cube feet in a lineal yard.	
Ft.	In.	Ft.	In.	Ft.	In.	Number.	Ft.	In.
0	9	0	4½	3	6	56	3	11
1	0	0	4½	4	4	69	4	11
1	0	0	9	11	0	176	12	4
1	2	0	4½	4	10	77	5	5
1	2	0	9	12	1	193	13	7
1	6	0	4½	5	11	95	6	8
1	6	0	9	14	2	226	16	0
2	0	0	4½	7	6	119	8	5
2	0	0	9	17	3	277	19	5
2	6	0	4½	9	0	145	10	1
2	6	0	9	20	5	327	23	0
3	0	0	4½	10	7	170	11	11
3	0	0	9	23	7	377	26	6
3	0	1	2	39	3	628	44	2
3	6	0	4½	12	2	195	13	8
3	6	0	9	26	8	427	30	0
3	6	1	2	44	0	704	49	6
4	0	0	4½	13	9	220	15	5
4	0	0	9	29	10	477	33	7
4	0	1	2	48	9	780	54	10
4	6	0	4½	15	4	245	17	3
4	6	0	9	33	0	528	37	1
4	6	1	2	53	5	854	60	1
5	0	0	4½	16	10	270	18	11
5	0	0	9	36	2	578	40	8
5	0	1	2	58	2	930	65	5
5	0	1	6	81	8	1307	92	0
5	6	0	4½	18	6	295	20	9
5	6	0	9	39	3	626	44	2
5	6	1	2	62	10	1005	70	8
5	6	1	6	88	0	1408	99	0
6	0	0	4½	20	0	320	22	6
6	0	0	9	42	5	678	47	8
6	0	1	2	67	7	081	76	0
6	0	1	6	94	3	509	106	0

This rule applies to wells, barrel drains, &c.

All heads or footings to be added extra.

In this table, to reduce the 1½ reduced brickwork to cubic feet, multiply by 9 and divide by 8.

NOTE.—If the brickwork be laid dry, as in cesspools and wells, the number of bricks will be about one-tenth more.

Table, showing how many bricks are sufficient to build a wall, the superficial amount being given, from 1 to 90,000, from half a brick to two and a half bricks thick, at the rate of 4,500 bricks per rod, waste included.

THE NUMBER OF BRICKS THICK, AND THE QUANTITY REQUIRED.

Super. area of wall. ft.	½ brick	1 brick	1½ brick	2 brick	2½ brick
1	5	11	16	22	27
2	11	22	33	44	55
3	16	33	49	66	82
4	22	44	66	88	110
5	27	55	82	110	137
6	33	66	99	132	165
7	38	77	115	154	193
8	44	88	132	176	220
9	49	99	148	198	248
10	55	110	165	220	275
20	110	220	330	441	551
30	165	330	496	661	827
40	220	441	661	882	1102
50	275	551	827	1102	1378
60	330	661	992	1323	1654
70	386	772	1158	1544	1930
80	441	882	1323	1764	2205
90	496	992	1488	1985	2481
100	551	1102	1654	2205	2757
200	1102	2205	3308	4411	5414
300	1654	3308	4963	6617	8272
400	2205	4411	6616	8823	11029
500	2757	5514	8271	11029	13786
600	3308	6617	9926	13235	16544
700	3860	7720	11580	15441	19301
800	4411	8823	13235	17647	22058
900	4963	9926	14889	19852	24816
1000	5514	11029	16554	22058	27573
2000	11029	22058	33088	44117	55147
3000	16544	33088	49632	66176	82720
4000	22058	44117	66176	88235	110294
5000	27573	55147	82720	110294	137876
6000	33088	66176	99264	132352	165441
7000	38602	77205	115808	154411	193014
8000	44177	88235	132352	176470	220588
9000	49632	99264	148896	198529	248161
10000	55147	110294	165441	220588	275735
20000	110294	220588	330882	441176	551470
30000	165441	330882	496323	661764	827205
40000	220588	441176	661764	882352	1102960
50000	275735	551470	827205	1102940	1378675
60000	330882	661764	992646	1323528	1654410
70000	386029	772058	1158087	1544116	1930145
80000	441176	882352	1323528	1764704	2205880
90000	496323	992646	1488969	1985292	2481615

Weight of a cubic foot of newly built brickwork, 117 lbs. Weight of a rod of new brickwork, 16 tons.

Table showing the number of rods contained on the face of a wall, from half to five bricks in thickness, and reduced to the standard measure of one brick and a half thick.

	½ brick.			1 brick.			1½ brick.			2 brick.			2½ brick.			3 brick.			3½ brick.			4 brick.			4½ brick.			5 brick.		
	rd.	qr.	ft.	rd.	qr.	ft.	rd.	qr.	ft.	rd.	qr.	ft.	rd.	qr.	ft.	rd.	qr.	ft.	rd.	qr.	ft.	rd.	qr.	ft.	rd.	qr.	ft.	rd.	qr.	ft.
¼	0	0	22	0	0	45	0	1	0	0	1	22	0	1	45	0	2	0	0	2	22	0	2	45	0	3	0	0	3	22
½	0	0	45	0	1	22	0	2	0	0	2	45	0	3	22	1	0	0	1	0	45	1	1	22	1	2	0	1	2	45
¾	0	1	0	0	2	0	0	3	0	1	0	0	1	1	0	1	2	0	1	3	0	2	0	0	2	1	0	2	2	0
1	0	1	22	0	2	45	1	0	0	1	0	22	1	2	45	2	0	0	2	1	22	2	2	45	3	0	0	3	1	22
2	0	2	45	1	1	22	2	0	0	2	2	45	3	1	22	4	0	0	4	2	45	5	1	22	6	0	0	6	2	45
3	1	0	0	2	0	0	3	0	0	4	0	0	5	0	0	6	0	0	7	0	0	8	0	0	9	0	0	10	0	0
4	1	1	22	2	2	45	4	0	0	5	1	22	6	2	45	8	0	0	9	1	22	10	2	45	12	0	0	13	1	22
5	1	2	45	3	1	22	5	0	0	6	2	45	8	1	22	10	0	0	11	2	45	12	1	22	15	0	0	16	2	45
6	2	0	0	4	0	0	6	0	0	8	0	0	10	0	0	12	0	0	14	0	0	16	0	0	18	0	0	20	0	0
7	2	1	22	4	2	45	7	0	0	9	1	22	11	2	45	14	0	0	16	1	22	18	2	45	21	0	0	23	1	22
8	2	2	45	5	1	22	8	0	0	10	2	45	13	1	22	16	0	0	18	2	45	21	1	22	24	0	0	26	2	45
9	3	0	0	6	0	0	9	0	0	12	0	0	15	0	0	18	0	0	21	0	0	24	0	0	27	0	0	30	0	0
10	3	1	22	6	2	45	10	0	0	13	1	22	16	2	45	20	0	0	23	1	22	26	2	45	30	0	0	33	1	22
11	3	2	45	7	1	22	11	0	0	14	2	45	18	1	22	22	0	0	25	2	45	29	1	22	33	0	0	36	2	45
12	4	0	0	8	0	0	12	0	0	16	0	0	20	0	0	24	0	0	28	0	0	32	0	0	36	0	0	40	0	0
13	4	1	22	8	2	45	13	0	0	17	1	22	21	2	45	26	0	0	30	1	22	34	2	45	39	0	0	43	1	22
14	4	2	45	9	1	22	14	0	0	18	2	45	23	1	22	28	0	0	32	2	45	37	1	22	42	0	0	46	2	45
15	5	0	0	10	0	0	15	0	0	20	0	0	25	0	0	30	0	0	35	0	0	40	0	0	45	0	0	50	0	0
16	5	1	22	10	2	45	16	0	0	21	1	22	26	2	45	32	0	0	37	1	22	42	2	45	48	0	0	53	1	22
17	5	2	45	11	1	22	17	0	0	22	2	45	28	1	22	34	0	0	39	2	45	45	1	22	51	0	0	56	2	45
18	6	0	0	12	0	0	18	0	0	24	0	0	30	0	0	36	0	0	42	0	0	48	0	0	54	0	0	60	0	0
19	6	1	22	12	2	45	19	0	0	25	1	22	31	2	45	38	0	0	44	1	22	50	2	45	57	0	0	63	1	22
20	6	2	45	13	1	22	20	0	0	27	2	45	33	1	22	40	0	0	46	2	45	53	1	22	60	0	0	66	2	45
21	7	0	0	14	0	0	21	0	0	28	0	0	35	0	0	42	0	0	49	0	0	56	0	0	63	0	0	70	0	0

BRICKWORK.

BRICKS.—The qualities which are aimed at in making bricks, and which should be sought after in the selection of bricks for building purposes, are: Soundness and hardness, regularity of form and size, that they may lay evenly and bond well; uniformity of colour, that they may look well in all faces; facility of cutting, that the workman may be able to cut them without breaking them to pieces, and reduce them to the shape required for all gauged work.

The earths most suitable for brickmaking are of three kinds; 1st, the clays, consisting mostly of one-third alumina, and two-thirds silica, with which, however, many foreign substances are often combined, as lime, magnesia, iron, &c.; 2nd, loams; 3rd, marls. Each of these is generally improved by mixing one with the other. The addition of sand to very clayey earths prevents the *excessive* contraction and consequent rending which such earths would be liable to in firing; the addition of chalk, to some extent, effects the same object, but, besides this, it acts as a flux to melt the siliceous particles, and, at the same time, to correct chemically the effects of an overdose of sand. According to Dr. Ure, the most fusible compound of these earths consists of 1 part of lime, 1 of pure clay, and 3 of sand, mixed together at the same time; with 5 of sand the compound becomes infusible.

It is to be remembered that, without making any scientific pretensions to correct proportions of these earths, which, however, would never do any mischief, they are nevertheless of great importance, both as regards the bricks made, and economy in making them. It is indeed so important, that in those brickyards connected with pits where

there is a great variety of these earths, the best bricks, both as regards colour and soundness, are produced when once the character of the different varieties is understood.

Iron in clay tends to give a red colour to the bricks; alumina and silica, or pure clay and sand, to produce a white colour, and the bright buff often depends on the nature of the sand, the common sand often burning of a reddish colour.

In brick-making all vegetable mould is to be got rid of, and every one accustomed to look at bricks must have noticed that wherever there is a stone, even a small pebble, there is a crack or defect in the brick; these, therefore, must be washed or picked out. The chemical action of a bit of limestone is equally mischievous. Our meeting with these substances depends of course, to a considerable extent, on the part of the country where we are at work, and on the nature of the pits from which the earths are extracted. Some will require much more washing and picking than others, and also more working, and the amount of labour in carrying them out will also be more or less in proportion to the quality of the brick we have to produce. By good washing, we not only get rid of all stones, but also a more thorough mechanical, and even chemical, mixture of the earths used.

Washing, however, will not always by any means produce this necessary mixture and incorporation of the various elements of brick earths; rolling and crushing have to be resorted to, accordingly as the earths are more or less naturally indurated, or accordingly as we meet more or less with ironstone and limestone, gypsum, &c.

Where the bricks are to be produced rapidly, the best way almost always is to use the rollers at once. When a large quantity of bricks is required in a short time, and

soundness is the principal condition sought, and provided always that the earth to be procured contains the necessary elements of brick earth, it may be dug up at once, watered, chopped, and trodden, and stones picked out, and wheeled to the rolling mills; after which it may be turned over once or twice, and then passed over to the moulders. The first manual working fits the material to go readily through the rolling operation, on the complete action of which will, in a great measure, depend the soundness of the bricks produced.

For large quantities, steam power or water power will be used for doing the work, and hollow cast iron cylinders, or stones, will be used for rollers according to circumstances. When, however, we do not have recourse to the time-honoured process of tempering by hand, frost, and weathering, the operation of rolling may be said to be indispensable. Attention is required to see that the gauge be not sufficiently wide to allow coarse materials to pass through.

For works such as are now contemplated, we should not recommend the use of any other moulds than the brass moulds, for the operation of moulding the bricks; they save much labour, and are therefore economical in the end. They are generally made of cast brass in four pieces, the metal being made so that the brass overlaps the wooden outside, which is added afterwards to stiffen the sides of the mould.

We also prefer sand or pallet moulding, in which operation sand is used to the mould to prevent it adhering to the sides of the mould, instead of water. The clay being brought to the right hand of the moulder's table, a clot sufficiently large is rolled and tapped into the approximate form; this is done by the moulder or his help; it is then thrown sharply into the mould, pressed in, and the surplus

stricken off, both the hands and the strike being well wetted in the operation.

Every moulding table should be provided with a "stock board," on which there is a projection to form the kick in the bottom of the brick in the moulding.

After burning, the bricks are separated for sale, according to the manner and degree in which they have been burnt, as, "*hard sound stocks;*" "*place,*" or *inferior soft bricks;* and *clinkers* or *burrs*, which are over burnt. Again, stock bricks are divided into *picked stocks*, *red*, and *grey* stocks. A greater variety of denominations is often to be met with, such as *red facing bricks*, *red kiln stocks*, *White Suffolk bricks*, *Cowley and Kent bricks*, *cutters*, or bricks that cut and rub well, *yellow and pale malm bricks*, *marle cutters*, *yellow seconds*, *pale seconds;* the *Stourbridge*, *Welsh*, and *Windsor fire bricks*, made from fire clays, composed of silica and alumina free from magnesia, lime, and metallic oxides. The Stourbridge occupy the first position as fire bricks, being capable of resisting an intense heat; the Windsor fire clay is much used in London for fire work; the *blue*, *red*, and *drab* Staffordshire bricks, the latter of which is used as a fire brick by potters and iron masters; also the Staffordshire blue paviour. Besides these, there are ventilating and perforated bricks, and a great number of bricks of particular forms.

BRICKWORK BOND.

As already observed on the subject of masonry, so it may be said also of brickwork, that the strength of the work depends greatly on the manner in which the bricks are arranged or bonded in the work. Taking the standard size

of the brick at 9 inches in length, $4\frac{1}{2}$ inches in width, and $2\frac{3}{4}$ inches in height, we have to consider that, for bringing in these dimensions in good work, as at the returns of walls, and the openings for doors and windows, it is often necessary to introduce a quarter, a half, or a three-quarter brick; these are called *closers*, in distinction from *a bat*, which is a piece of brick accidentally broken, which it is often necessary to prevent being used in good brickwork, otherwise than as above, and more particularly in face work, if it be only to prevent the carelessness of the workman in the handling of the material.

There are four kinds of bond commonly recognised; as, *Flemish bond*, *English bond*, *Herringbone bond*, and *Garden-wall bond*. In English bond, the bricks in one course are all placed as stretchers, and in the next course they are all placed as headers. In Flemish bond, the bricks are all laid alternately as headers and stretchers in the same course, the headers in each course standing centrally between the stretchers in the adjoining courses, and thus producing an arrangement of the joints in the face of the work which is agreeable to the eye.

Herringbone bond is principally applied to thick walls, and is not so much introduced at present as it was formerly. In this description of bond, the interior bricks, or hearting of the wall, are laid obliquely at an angle of 45°; in the next course, this oblique direction is reversed, so that course after course the oblique joints cross each other at right angles. It makes a good hearting, but is somewhat wasteful.

Garden-wall bond is applicable for nine-inch walling. Three stretchers are here laid to one header.

In English and Flemish bond, for thick walls, the faces being formed in the above-mentioned manner, the interior

of the wall is filled in with bricks, often laid in a variety of ways, so as to produce good bond and avoid one joint or a line of joints coming over another line of joints; this, indeed, is the principal object of bond. In first-class work, whole bricks only are allowed to be introduced in the work, although sound half and three-quartes bricks may very often be allowed, and in some cases even with advantage. The capital sin of bricklayers which has to be avoided is the introduction of broken pieces of brick, which not only are defective in themselves, but are often got in in such a manner as to spoil the bond at some distance from the place where the broken bits have been brought into the work. It often occasions the necessity of filling up with rough mortar. It should never be allowed; and the workmen are so perfectly aware of it that they manage to stand over it, or throw a jacket or a board over it, when they see an inspector or other superintendent coming to visit the work.

Of the English and Flemish bonds, it is fashionable to eulogise the former, and decry the latter as being *very well to look at*, but *bad to stand.* On the other hand, the "particular vanity" of others is to swear by the reverse. All these notions, or pretended notions, are so many fallacies. But then, it would not do for any man not to have his "particular vanity" to swear by as well as his neighbour: only mind in this, as in all other such matters, always get to the strongest side; the other is a losing game.

Walls, however, of some thicknesses cannot be constructed of either bond, according to strict principles, without using closers of half or three-quarter bricks. Thus a wall one and a half brick thick cannot be constructed in English bond, without either laying it in one row of headers with one of stretchers, thus having a continuous joint longitudinally through the course or making out the thickness of

the wall by laying a half-brick at the end of each header, both of which plans are defective.

The stretcher courses also, if strictly preserved, will have two parallel vertical joints running longitudinally through the wall, and thus impose the whole duty of cohesion upon the mortar joint. Now, a wall of the same thickness may be constructed with Flemish bond, not indeed without half-bricks, but by laying them entirely within the wall itself.

Hoop-iron with holes punched in it at about every six inches, dipped hot in creosote and sanded, is a great strengthener in all brick walling. $3\frac{3}{4}$ lbs. per ten feet lineal is very suitable.

Good bricks are always heavy, solid, and compact, shapely, and with sharp edges, and they will absorb but little water; struck together, they ring with a sharp, clear sound. To choose between two bricks of nearly equal weight, weigh them, and then let them soak twenty-four hours in water; when they are taken out and weighed again, choose that which has imbibed the least water. Overburnt bricks may be heavy, but they are cracked and warped from too much firing. Bad bricks, on the contrary, are light, have no ring in them, are of all manner of shapes, and make a man's eyes ache to look at them; their edges are broken, and they suck up any quantity of water.

Good brickwork is laid true to bond, with thin joints, in accurately horizontal courses, every part of the face work and every joint in it answers truly to the plumb-line, there is no winding in the face and no twisted arrises. All the joints and beds are well filled in with mortar, and the bricks are pressed into it until it oozes out at the joints. All deficiencies in the face work are carefully pointed up as the work proceeds, and the whole is well flushed up as the work is carried up, course by course. Avoid laying up good

brickwork "*in a larry.*" The mortar is well mixed and well worked; the lime is carefully fallen and slaked; the lime and sand are thoroughly incorporated; the sand, by itself, feels clean and sharp to the touch between the fingers, and free of all greasy and tenacious matter. The lime and sand to be mixed 3½ of sand to 1 of lime in the bulk; no bag lime on large works. For face work, a larger proportion of lime may be used. The external joints will thus oppose a greater resistance to the admission of damp, and an economy is effected by using less lime in the internal and protected parts of the work.

In using cement, one and a half of clean sharp sand may be mixed with it.

The joints should never exceed one quarter of an inch in thickness, and the vertical joints should all be truly plumb over each other in the different courses accordingly as intended by the kind of bond employed.

The work should be carried up uniformly throughout its length and thickness, and no difference allowed exceeding four courses. *Unequal* settlement is the sure result of any other course of proceeding in this respect.

Contraction of bulk, or settlement, must occur from the drying of such materials as mortar used in an expanded condition, and therefore we know that our walls must settle as the work dries; but to prevent rupture, this settlement must be uniform and simultaneous throughout the length of a wall; and this can only be insured by attending to the conditions imposed above. For the self-same reasons, the back and interior of the work must be brought up at the same time as the face.

Mortar should be used comparatively thick, and not in a sloppy state, the degree of plasticity required being simply that which will ensure its perfect distribution and penetra-

tion throughout the beds and joints. It is very necessary, more particularly in hot weather, that the bricks be thoroughly wetted on the surface; it washes away the dust, and secures adhesion between the bricks and the mortar. When this precaution is neglected, it will be found that a brick newly laid is very easily lifted from off its bed. Thin watery mortar must contract very largely, and consequently great settlement in the work must ensue.

GENERAL SPECIFICATION FOR BRICKWORK.*

The bricks used throughout the works shall be the best, new, sound, well-shaped, and hard-burnt bricks, free from all defects to the satisfaction of ———, and on no account shall bricks of various dimensions be used in the works. All the best-shaped and best-coloured bricks shall be reserved for the face work.

No four courses with three joints must exceed in thickness, when built, ¾ of an inch more than the same bricks measured when piled dry on each other.

No bats shall be used, unless when it may be necessary to use them as closers for acquiring the required dimensions of the different courses.

The bricks must be well saturated with water.

All the upper courses of brick copings, offsets, cornices, plinths, which are exposed to the weather, must be set in an approved cement.

The bricks shall be bedded sound, and flushed with mortar at least at every second course.

* For further information, see Professor Donaldson's "Specifications."

The work must be finished, in all face work, with a neat drawn joint, and pointed.

In setting the bricks in arches, they are to be well pressed into their beds, so as to squeeze the mortar out and leave the joint thin; and all the bricks to be laid with properly radiating beds.

Specify for the hoop-iron, as mentioned above, according to the thickness of the wall.

HYDRAULIC LIME.—MORTAR.—CONCRETE.

The grey stone limes Merstham and Dorking, were some time since great favourites generally, and there is no doubt that excellent mortars may be, and are still indeed, produced from those limes. Lately, however, the tide of popular and professional favour has set in altogether towards the lime produced from the blue lias of Aberthaw, Lyme Regis, &c.; this lime is eminently hydraulic, and a mortar is produced which sets permanently and hardens under water. Equally fine mortars, however, are produced from the Yorkshire Clitheroe, the Halkin mountain, and the Ardwick limes.

The best hydraulic limes usually commence to set two days after immersion, and become quite hard in the course of a month; others remain 4 or 5 days before the setting commences.

The French engineer Descotils inferred (A.D. 1813) that silica was the element to which the hydraulic properties of lime were due, an opinion which is now generally received.

Mr. George Robertson informs us that, for the works lately constructed for the extension of the London Docks, where large masses of concrete were made, the Dorsetshire lias was the only lime burnt on the works.

Lias requires much greater care in burning than richer limes, because any sudden or extra heat, which would do little harm to Dorking lime, greatly injures lias, by forming a glass between the silica and the lime in the stone, instead of only driving off the water and the carbonic acid.

The combination between the silica and the lime, to which lias owes its hydraulic properties, ought only to take place in the humid way; that is to say, with the assistance of water, after the application of the lime as mortar or cement.

Lias comes from Lyme Regis in two different forms—the one with a clean conchoidal fracture, and the other of a shaly nature, approaching even in appearance to clay slate, but quite soft. The shaly lias, which contains so much clay as to have the properties of a cement, is not so desirable as the hard clean stone, because it carries less sand, and is therefore more expensive.

The stone costs 4s. 3d. per ton when shipped at Lyme, but 10s. 9d. before it is stacked round the kiln at London, which is as much as the same stone costs delivered at the works of the new graving docks at Leith. Freight to London is always heavy, for there is no steady return freight like coal to be had.

Notwithstanding the high price of the stone delivered at Shadwell, and having to pay freight on thousands of tons of water to be afterwards driven off by the heat of the kiln, the late Mr. Rendel decided on burning the limestone in London. It was very desirable to have the best possible lime where concrete was to play so important a part. This talented engineer's large experience in hydraulic works affords a sufficient warranty that he had sound and substantial reasons for such a proceeding; no doubt he knew full well the difficulty of obtaining good lime in the ordinary trade way.

Two egg-shaped draw kilns were erected, 43 feet high from the floor to the top of the dome, and of an extreme internal diameter of 14 feet, contracting to 5 feet at the fire bars, and 11 feet 6 inches at 32 feet above the floor.

The practical objection to a less diameter at the top is

the difficulty arising in charging the kiln with evenly distributed layers of coal and stone tipped in from barrows at the top through the windows in the dome. A contracted top, it has been considered, to a kiln, prevents the escape of carbonic acid, although it has a counterbalancing advantage in confining the heat and throwing it down with a reverberating effect on the charge. The theoretical objection appears fanciful, and it was found necessary after the kilns had been some time at work, to dome the mouth over with a brick arch to prevent stones from flying into the neighbouring streets. The chimney at the top of this was only 3 feet diameter, but no difference was perceptible in the time required for burning, or in the percentage of imperfectly burnt stone. On the other hand the dome appears to have acted economically in the coal required . . . .
An average of 11½ tons of stone burned by one ton of coal is very high; but the coal was Welsh, and cost £1 1s. per ton. Bituminous coal was inadmissible on account of the situation. At Leith, one ton of coal of the neighbourhood appears to burn only 6 or 7 tons of lias, but it is only one-third the price of Welsh coal.

Barrows of coal and broken stone were lifted to the top of the kiln by a hoist worked by a mortar mill engine, and were tipped in as evenly as possible, through three openings in each dome. After the fire was lighted, these openings were kept closed with boiler plate shutters. The cost of charging, including breaking up of stone and coal, was 1s. 6d. per ton of the two. Unless when the demand for quicklime was very irregular, the kilns were always kept lighted; when they were allowed to go out, the charge was left in the kiln as the driest place.

Whenever the fire is let out in draw kilns, the next charge is nearly sure to burn irregularly, and there is considerable

loss of heat in rewarming the kiln. Draw kilns are liable to irregularity from apparently slight causes, such as the direction of the wind, &c., and in the Shadwell kilns there was also a permanent tendency to burn quickest down the side warmed by the adjacent kiln, for they were both in one block of building; but draw kilns are better adapted for burning lias than flare kilns, as the heat is more uniformly distributed through the charge, and there is therefore less danger of over-burning the lower half and under-burning the upper.

Each kiln contained 100 tons of stone and burnt 21 tons per diem.

The two together produced 25 tons of quick lime every day, a quantity sufficent for about 97 cubic yards of mortar, and 170 cubic yards of cement. 9 tons of coal will burn 100 tons of stone, which will produce 59·37 *tons of quick lime*, or 1,583 bushels of *ground lime*, 3,063 bushels of *slaked lime*, enough for 400 cubic yards of concrete, when the ballast is moderately dry, 231½ cubic yards of first-class mortar, and 262½ cubic yards of second-class mortar.

Drawing the lime from the kiln cost 1¼d. per ton of quick lime. The total cost of the burnt lime amounted to 24s. per ton.

When quite hot from the kiln, 26½ bushels of ground lime went to the ton; but after keeping some time, *a ton swelled to* 30 *bushels*, which is what bought lias usually weighs.

A bushel of lime, ground when fresh burnt, contains, therefore, one-seventh more lime than a bushel of stale lime; and a cubic yard of concrete, of specified proportions, is so much the better when made with fresh lime.

Coke was used, but it was found 8 per cent. dearer than Welsh coal, and the percentage of unburnt stone was raised much above the usual average of 1½ or 2 per cent.

The equally burnt and softest lumps, usually of a buff colour, were picked out for grinding, and the remainder, more of a liver colour, slaked for mortar.

The lumps were first broken tolerably small by hand, and then crushed still smaller between iron rollers revolving in the hopper of the grindstones. These rollers were at first made fluted, but it was found that strong projecting cogs did the work more effectually.

The hopper was fed with lumps of lime by an endless chain of small wrought iron buckets, worked by the engine: these it was found necessary to supply by manual labour.

The lime was ground to a fine powder between two pairs of horizontal French burr millstones, the upper one revolving at a speed of 90 revolutions per minute.

Each pair of stones was able to grind 3 tons of quicklime per hour, at a total cost of grinding of 1d. per bushel, when the consumption was 300 bushels per diem; less, if more lime was used.

This is made up as follows:—

Feeding and attending to the hopper and lift	½d.
Engine power	¼d.
Measuring the lime into bags, and recutting the furrows as the stones became worn...	¼d.

A bushel of ground lime fresh from the kiln weighed 84 lbs., and at this weight the total cost was 11¾d. In buying ground lime from the merchant, if the purchaser buys by weight, he pays for the water which the lime has absorbed, and if by measure, then he pays for the expansion arising from the same cause. The fairest way would be to allow 80 lbs. to the bushel of lime.

Regis Lias.—In making the concrete, it was found that when the ballast was moderately dry, 12 cubic yards of

gravel and 2 cubic yards of lime, made 11 cubic yards of concrete, mixed and deposited.

The shrinkage from the dry materials was then 22 per cent.; but if the ballast happened to be very dry, the shrinkage was more, and the same quantities made only 10 cubic yards.

A cubic yard of concrete requires about 38 gallons of water to bring the dry materials to the requisite state of fluidity; of this quantity, nearly 8 gallons enter into chemical combination with the oxide of calcium in the lias, and 30 gallons are either absorbed mechanically by the pores of the lime, retained by capillary attraction between the grains of sand, or lost by evaporation.

Concrete, in setting, expands gradually, and the less this takes place the better, as it of course disturbs the solidifying of the material.

In hot summer weather, the expansion of a cubic foot of concrete, in 24 hours after mixing, was as much as one-thirtieth of its bulk, but rarely exceeded one-forty-eighth in frosty weather.

In making blocks of concrete which have to be lifted, recourse must be had to slaked lime, or cement, when the friability arising from this swelling will be avoided; but the concrete is longer in hardening.

The gravel and lime were mixed together on a platform of planks, *as they invariably should be*, and were turned over twice in a dry state, and twice with water gradually added. The concrete was then wheeled in barrows and shot into the required place from planks a few feet above the place of deposit.

The idea that concrete should be thrown in from a great height is erroneous, for it then falls with too great force, disturbs the setting of the mass, causing friability, and brings the lime to the top.

The evil effects of a great fall were particularly noticeable in deep pits, where the concrete was thrown from a height of 30 feet. The force of the blow sets the whole mass in motion for some feet down.

The grand rule in concrete is never to disturb it after setting has once commenced; and punning is particularly objectionable.

At 10d. per bushel for ground lias lime, the price for concrete, per cubic yard, is made up as follows:—

	s.	d.
3¾ bushels of lime at 10d.	3	1½
Loading, waste, and bags for ditto ...	0	3
Getting gravel (on the spot)	0	6
Wheeling ditto, say 5 runs...	0	4
Screening and selecting ditto	0	3
Mixing and depositing	1	1
Platforms	0	1½
Total cost per cubic yard	5	8

In the London Dock extensions, concrete was supplied in the following ways: in foundations for brickwork and masonry, as a means of spreading the weight over a large surface; in the dock walls themselves, wherever the concrete would not be exposed to the alternate action of wind and water; as counterforts or buttresses, on which nothing was to be afterwards built, but when weight was wanted. It was, in almost all respects, very similarly applied at the Brentford Docks, under the late Mr. I. K. Brunel.

The whole of the walls and iron columns of the new warehouse rested on trenches of concrete about 8 feet wide, and averaging, perhaps, 8 feet thick: as this concrete was not to be exposed to the direct action of water, it was made of Dorking, or grey stone lime, in the proportion of 1 of ground lime to 8 of ballast. This lime is commonly used in London

for building purposes, and, although feebly hydraulic, is, when mixed with pozzuolana, used even in dock work.

A quick-setting concrete is made of 1 of cement and 9 of ballast.

MORTAR.

One of the most important materials in all good building is mortar, and it is proportionately difficult to attain. To make good mortar, we must have good lime and good sand, or clean, well-burnt furnace ashes, when sand cannot be procured.

The lime should be thoroughly calcined, so as to have expelled all carbonic acid; and it should not be stale, but fresh burnt, so as not to have imbibed moisture from the atmosphere, which it has a powerful and constant tendency to do. See what has been said above on this subject under the head of Concrete. Stale or *dead* lime will never make mortar.

For slaking, the quicklime may be spread out in a layer 6 inches thick, and water thrown over it as evenly as possible, in the proportion of 74 gallons to the ton of lime. The decrepitating lime should then be shovelled up into heaps, and covered with sand until required.

The sand is to be clean and sharp, free from soil and all vegetable matter, and well screened, if required, through a screen not coarser than four meshes to the inch, for brickwork. If necessary, the sand should be washed.

Where any large quantities of mortar are to be used, the mortar should be ground under edge stones.

It was found, at the London Docks' extension, that the adhesion of the mortar was increased up to 600 revolutions

of pans; after which it was injured, by the gradual formation of silicates, with their accompanying result, friability. Up to the same point, the density of mortar was also increased; but if the grinding was long continued, the mortar began to swell, with a puffy look and feel, caused by the water beaten up with it.

Mr. Hosking gives the following as a mortar capable of resisting the action of fire:—

"An excellent mortar for resisting the action of fire, and proper to be employed in building any such slight brick piers, as substitutes for, or instead of employing, iron columns, may be made of pozzuolana, mixed with fresh ground lime of chalk from the lower beds. And as real pozzuolana is an imported substance, and likely to be expensive, its place may be very well supplied by an artificial substance of similar character, produced by burning any marly clay that is fit for brick-making to a grey clinker, and reducing such clinker to a grain of the size of coarse sand. Three-fourths of this substance to one-fourth of fresh ground lime, mixed dry in the first instance, and when so mixed rendered plastic by the addition of soft water, will yield a mortar capable of resisting fire for a long time, and water, if need be, as long as any bricks that can be set in it."

TIMBER AND CARPENTRY.

The Timber mostly in use for building purposes is Fir, which is imported from Memel, Riga, Dantzig, and Sweden. Memel is the most convenient for size, and Riga is considered the best in quality, Swedish the toughest, and Dantzig is looked upon as the strongest. Pine is used occasionally, where great evenness of grain and freedom of knots are desirable.

In making choice of timber, avoid large and dead knots, a coarse loose grain, and spongy heart, and select that with a bright, close, fine grain.

The deals from Norway, particularly the Christiana, are considered the best for framing. The yellow and white pines are the best woods for clean joinery purposes.

TRANSVERSE STRENGTH OF TIMBER.

(Rule.)—To ascertain the breaking weight of a beam supported at each end, and loaded at the centre,

$$W = \frac{4 \times b \times d^2 \times S}{L}$$

in which W, the breaking weight in lbs.; b, the breadth; d, the depth; L, the length in inches, and S, a constant given in the following table.

Example.—Required the weight applied in the centre that will break a beam of Riga fir 20 feet long, 10 inches deep, and 8 inches broad; the above formula will become,

$$\frac{4 \times 8 \times 10^2 \times 1051}{240} = 14{,}013 \text{ lbs. breaking weight.}$$

Having the breadth, the depth, and the weight as above, to find the length :—

$$L=\frac{S\times b\times d^2}{W}$$

Taking the same dimensions as before, we shall have

$$\frac{10\times 51\times 8d^2}{14013}=240 \text{ inches, the length of the beam.}$$

Under the like circumstances, we may find the breadth of the beam, of which we have the length, the depth, and the breaking weight.

Example.—Suppose that we have a beam of Riga fir, 25 feet long, supported at both ends, having a load to carry in the centre of 7 tons, and that we assume three times this load, or 21 tons, as the breaking weight; suppose, further, that circumstances will not permit us to give the beam a greater depth than 14 inches, then we have to find the breadth we shall have to give the beam. We have the following formula to find this breadth :—

$$b=\frac{L\ W}{4d^2\ S}$$

or the length multiplied by the breaking weight, and the product divided by 4 times the square of the depth multiplied by the tabular constant S, gives the breadth required; and with the above example we shall have the following in figures :—

$$\frac{300\times 47040}{4\times 15^2\times 1051} \text{ or } \frac{14112000}{945900}=15 \text{ inches very nearly.}$$

Similarly, where we require the depth, having all the other expressions given, we have the following :—

$$d=\sqrt{\frac{L\times W}{4\times b\times S}}$$

or multiply the breaking weight by the length of the beam, divide the product by 4 times the breadth multiplied by the tabular constant, and extract the square root of the quotient for the depth of the beam.

Where the beam is *fixed* at one end and loaded *at the other*, we have—

$$W=\frac{b\times d^2\times S}{L}$$

the notations being as before; that is, $b=$ the breadth, $d=$ the depth, $L=$ the length, all in inches; $W=$ the breaking weight in lbs., and S the tabular constant.

Example.—Required, the breaking weight of a beam 10 feet long, 8 inches broad, and 10 inches deep, for a beam of red pine, for which the constant of transverse strength is 1341.

The formula becomes—

$$\frac{8\times10^2\times1341}{10}\text{ or }\frac{8\times10^2\times1341}{120}=\frac{8\times100\times1341}{120}=8940\text{lbs.}$$

for breaking weight.

All other notations remaining as above, required the depth for a beam *fixed* at one end and loaded at the other; we shall have—

$$d=\sqrt{\frac{W\times L}{b\times S}}$$

or,

$$\sqrt{\frac{8940\times120}{8\times1341}}=10\text{ inches, the depth of the beam.}$$

If we have the length, the depth, and the breaking weight, and we require *the breadth* for a beam fixed at one end and loaded at the other, we may take the following formula:—

$$b=\frac{L\times W}{d^2\times S}$$

or, with the above example, but where we require the breadth, instead of the depth, we shall have—

$$\frac{120\times 8940}{10^2\times S}=8 \text{ inches, for the breadth.}$$

When the beam is supported at one end and loaded at the centre, we have—

$$W=\frac{4\times b\times d^2\times S}{L}$$

where $b=$ the breadth, $d=$ the depth, $L=$ the length, all in inches, $W=$ the breaking weight, and $S=$ the tabular constant.

Example.—Required, the breaking weight of a beam of red pine, 8 feet long, 8 inches wide, and 10 inches deep, supported at one end and loaded at the centre. We shall have from the above—

$$\frac{4\times 8\times 10\quad\times 1341}{96}=4470 \text{ lbs., breaking weight.}$$

If, under the same conditions of supported at one end and loaded at the centre, we require the depth of the beam we shall have—

$$d=\sqrt{\frac{L\times W}{4\times b\times S}}$$

or,

$$\frac{96\times 4470}{4\times 8\times 1341}=10 \text{ inches, the depth of the beam,}$$

and for the breadth,

$$b=\frac{L\times W}{4\times d^2\times S}$$

or,

$$\frac{96\times4470}{4\times100\times1341}=8 \text{ inches, the breadth of the beam.}$$

In the above, it will be necessary to remember that a load uniformly distributed over the length of a beam or girder is equivalent to half a load placed at the centre; thus the effects of 10 tons distributed over the length of the beam are taken as equivalent to 5 tons collected at the centre of such beam.

When the girder is supported at both ends and loaded at any intermediate point, as at $\frac{1}{3}$ or $\frac{1}{4}$ of its length, we have the following formula for finding the breaking weight:—

$$W=\frac{L\times b\times d^2\times S}{M}$$

where $L=$ the length, $b=$ the breadth, and $d=$ the depth of the beam, all in inches, $W=$ the breaking weight, $S=$ the tabular constant, and $M=$the multiple of the segments into which the length of the girder is divided.

Example.—Required the breaking weight of a beam of Riga fir, 15 feet long, 10 inches deep, 8 inches broad, loaded at 6 feet from one end. The constant is 1051, and M will be $=9\times6=108\times72$ in inches, and we shall have,

$$\frac{180\times8\times100\times1051}{108\times72}=19463 \text{ lbs. breaking weight,}$$

with the load at the given point.

Where, in such a case as the above, we require the depth of the beam, we have the following formula:—

$$d=\sqrt{\frac{M\times W}{L\times b\times S}}$$

and similarly for the breadth,

$$b=\sqrt{\frac{M\times W}{L\times d^2\times S}}$$

DEFLECTION OF BEAMS.

To find the deflection, in inches, of a beam supported at both ends and loaded at the centre, we have,

$$D=\frac{L^3 \times W}{d^3 \times b \times E}$$

where $D=$ deflection in inches, $L=$ the length, $d=$ the depth, $b=$ the breadth of the beam, all in inches also, and E the tabular constant.

Where the beam is supported at both ends, but the load uniformly distributed, take five-eighths of the above, or,

$$D=\tfrac{5}{8}\,\frac{L^3 \times W}{d^3 \times b \times E}$$

Table of Constants, &c.

Description of Timber.	Specific Gravity.	Value of *S*.		Value of *E* for deflection.	Value of *C* for maximum tensile strength.	Weight of a cubic foot.
		Breaking Weight.	Safe Load.			
Riga Fir	·788	1051	350	247600		47
Ditto	·753	1108	369	332200	10707	46
Mar Forest Fir...	·696	1144	381	161340	9539	43·5
Larch................	·560	1149	383	263200	7352	35
Ditto	·556	1127	375	263200	7655	34·75
Norway Spar	·577	1474	491	364400	12180	36·
New England Fir	·553	1102	367	547800	9947	34·5
Pitch Pine.........	·660	1632	544	306400	10415	41·5
Red Pine	·657	1341	447	460000	10000	41·25
English Oak......	·969	1181	393	218400	9836	60·5
Ditto	·934	1672	557	362800	10853	58·25
Canadian Oak ...	·872	1766	588	536200	11428	54·5
Dantzig Oak	·756	1457	485	297800	7386	47·25
Adriatic Oak......	·993	1383	461	243600	8808	62·
Elm	·553	1018	337	174960	5767	34·5
Beech	·696	1556	518	338400	9912	43·5
Ash	·760	2026	675	411200	17337	47·5
Teak	·745	2462	820	603600	15555	46·9

There exists as much difference in the strength of timber as there does in the strength of iron, and very much depends

on the way it has been treated, seasoned, &c. Loose knots are always a great defect. A beam with sound knots should always be fixed with the knots uppermost, and the same may be said of the natural camber of a beam. Where timber has been well and properly seasoned, and is in good condition, the heaviest is generally the strongest, the timbers compared being equally dry.

The transverse strength of a beam is as the breadth, multiplied by the square of the depth, and therefore every addition to the depth imparts a much greater addition to the strength than does any increase in the breadth of the beam; and therefore, of beams with equal sectional areas, those having the greatest depth will be best adapted to resist transverse strains.

Thus, if we have 100 square inches of sectional area of which to avail ourselves with any proportions we may please as to breadth and depth, we can dispose of them as in the following manner:—

Breadths.		Square of depths.		
10	×	10^2	=	1000
20	×	5^2	=	500
5	×	20^2	=	2000

The following old but simple and useful geometrical rule gives the strongest rectangular section which can be cut out from a tree:—

Let the sectional area of a tree be supposed a circle; draw a diameter, and divide it into three equal parts; from the two points of division within the circle draw two lines at right angles to the diameter to intersect the circumference (one on the right and the other on the left of the diameter; join the points of intersection with the extremities

of the diameter. The rectangle thus obtained will be the strongest that can be cut out of the tree.

100 superficial feet make one square of flooring, &c.

120 deals are denominated 100.

50 cubic feet of timber make one load.

600 superficial feet of inch boards make one load.

200 „ „ 3-inch planks make one load.

300 „ „ 2-inch „ „ one load.

400 „ „ 1½-inch „ „ one load.

12½ of twelve-feet boards go to one square of flooring.

12½ „ „ edges shot, ditto ditto.

13 „ „ wrought and laid folding, do. do.

14 „ „ ploughed and tongued, do. do.

12 „ battens, wrought and laid folding, do. do.

Battens are 7 inches in breadth, deals 9 inches, and planks 11 inches.

ROOFING.

Denominations and sizes of Slates.

Names.	Dimensions.	Weight per 1000.				Number or weight to one square	Price per 1000 of 1200, or per Ton.		
	Inches.					Cwt.	Per Ton.		
Queens . .	27 × 30	...			...	7½	£2	3s.	0d.
Do. . .	33 × 36	...			...	...	2	3	0
Princesses .	24 × *	...			...	...	2	0	0
		T.	C.	Q.	LBS.		Per 1000.		
Duchesses .	24 × 12	3	6	0	0	123	6	17	0
Do. . .	22 × 12	2	17	0	0	134	5	10	0
Countesses .	20 × 10	2	2	0	0	181	4	10	0
Viscountesses .	18 × 10	1	17	0	0	...	3	2	6
Ladies (large) .	16 × 10	1	13	0	0	...	2	10	0
Do. (middling)	16 × 8	1	7	0	0	266	2	0	0
Do. (small) .	14 × 8	1	2	0	0	...	1	2	6
Imperials .	30 × 24	...			...	8	...		...
Patent . .	30 × 24	...			...	8	...		...

* Various.

Table of Weight of Galvanised Sheet Iron for Roof-covering.

Size of sheets.			No. of gauge.	In parts of an in.	Weight per square ft.		Square feet per ton.
ft.		ft.			lb.	oz.	
6	×	6	12	$\frac{1}{9}$	4	8	497
6	×	6	14	$\frac{2}{25}$	3	8	640
6	×	6	16	$\frac{1}{16}$	2	8	896
6	×	6	18	$\frac{1}{21}$	2	2	1054
6	×	6	20	$\frac{1}{29}$	1	10	1378
6	×	6	22	$\frac{1}{34}$	1	5	1706
6	×	6	24	$\frac{1}{40}$	1	1	2108
6	×	6	26	$\frac{1}{50}$	0	15	2389
6	×	6	28	$\frac{1}{66}$	0	12	2986
4	×	20	30	$\frac{1}{83}$	0	10	3584
4	×	20	32	$\frac{1}{117}$	0	9	3982

A Table showing the Selling Prices of Plant.

Cranes.—For Wharves, strong pillar cranes with base plate to build into stone, single and double purchase, strap, break, &c., large ones, with radiating motion, to lift 1 ton, £41 10s.; to lift 2 tons, £54; to lift 3 tons, £70; to lift 5 tons, £105; to lift 10 tons, £170.

Crabs.—Double purchase, with strap break, 4 tons, £7 10s.; 6 tons, £9 9s.; 12 tons, £15 15s.; single purchase, 1 ton, £3 10s.; 2 tons, £5; 4 tons, £7; breaks, 25s. 6d. extra.

Crane Chains of the best make.

	Per yard.	Per cwt.
$\frac{3}{8}$ inch, proved and strained to $1\frac{1}{2}$ tons,	1s. 8d	35s.
$\frac{1}{2}$ " " " $3\frac{1}{2}$ "	2s. 0d	28s.
$\frac{3}{4}$ " " " 9 "	3s. 8d.	22s.

Circular Saw Table, 4 ft. by 2 ft., 24 in. saw, about £16.
Mortising machine with Tools, about £17.

LIFTING JACKS.—Cast frame, with wrought screw and iron bush, to lift 4 tons, 17 inches high, £2 10s.; to lift 2 tons, 15 inches high, £2; ditto in wood frame, to lift 2 tons, 2 ft. 3 inches high, £5; to lift 6 tons, 2 ft. 7 inches high, £7 7s.; to lift 12 tons, 3 ft. high, £10 10s.

TRAVERSING SCREW JACKS.—With double ratchet lever to main screw, to lift 10 tons, £11; to lift 15 tons, £14 14s.; to lift 20 tons, £16 16s.; to lift 25 tons, £18 18s.

GRINDSTONES.—With handle and foot treadle and spindle, mounted on friction roller, from £2 15s. to £3 10s.; the grindstone $12 \times 2\frac{1}{2}$, 2s. 3d. each; Newcastle stones, 24×4, 7s.; 42×6, 30s. each.

LADDERS.—12 rounds, 7d. per round; 30 rounds, 8d.; 45 rounds, 10d.; 60 rounds, 11d.; 80 rounds, 1s. 5d.

BARROWS.—Excavators, 10s. 6d.; ditto cleated and bolted, 18s.; Brickmakers, 25s.; iron wheels, 2s. 3d., wood ditto, 6s.

Brick Carts, to hold 500 bricks, £16; builders' hand carts on springs, £10; Cast iron portable forge, £5 to £5 10s.; stone trucks, 3 tons, £30; lime screens, 27s. to 35s.; gravel sieves, 3s.

Cubical Contents of a Square of Timber in Scantlings in Floors, Partitions, &c.

The Timbers are taken at 12 *inches apart, and an extra Joist allowed in a width of* 16 *ft. Plates, Heads, Sills, and Braces are not included.*

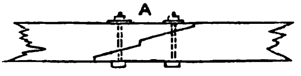
Depth	THICKNESS OF JOISTS OR PARTITIONS.															
	1½ Inch.		1¾ inch.		2 inch.		2¼ inch.		2½ inch.		2¾ inch.		3 inch.		3¼ inch.	
Ins.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
3	3	0	3	5	3	10	4	3	4	8	5	0	5	5	5	8
3¼	3	3	3	8	4	2	4	7	5	1	5	5	5	10	6	2
3½	3	6	4	0	4	6	4	11	5	5	5	10	6	3	6	7
3¾	3	9	4	3	4	8	5	3	5	10	6	3	6	8	7	0
4	4	0	4	7	5	1	5	8	6	2	6	8	7	2	7	6
4¼	4	3	4	10	5	5	6	0	6	7	7	1	7	8	8	0
4½	4	6	5	2	5	9	6	4	7	0	7	6	8	1	8	6
4¾	4	9	5	5	6	1	6	8	7	5	7	11	8	7	9	0
5	5	0	5	8	6	5	7	1	7	9	8	4	9	0	9	5
5¼	5	3	6	0	6	9	7	5	8	2	8	9	9	6	9	11
5½	5	6	6	3	7	0	7	9	8	6	9	2	9	11	10	5
5¾	5	9	6	6	7	4	8	1	8	11	9	7	10	5	10	11
6	6	0	6	10	7	8	8	6	9	3	10	0	10	10	11	4
6¼	6	3	7	1	8	0	8	10	9	8	10	5	11	3	11	10
6½	6	6	7	5	8	4	9	2	10	1	10	10	11	8	12	4
6¾	6	9	7	8	8	8	9	6	10	5	11	3	12	1	12	10
7	7	0	8	0	9	0	9	11	10	10	11	9	12	7	13	5
7¼	7	3	8	3	9	4	10	3	11	3	12	2	13	1	13	9
7½	7	6	8	7	9	8	10	7	11	8	12	7	13	6	14	2
7¾	7	9	8	10	10	0	11	0	12	0	13	0	14	0	14	8
8	8	0	9	1	10	3	11	4	12	4	13	3	14	5	15	1
8¼	8	3	9	4	10	7	11	8	12	9	13	10	14	10	15	7
8½	8	6	9	8	10	11	12	0	13	2	14	3	15	3	16	1
8¾	8	9	10	0	11	3	12	4	13	7	14	8	15	8	16	7
9	9	0	10	3	11	6	12	9	13	11	15	1	16	2	17	0
9¼	9	3	10	7	11	10	13	1	14	3	15	6	16	8	17	6
9½	9	6	10	10	12	2	13	5	14	7	15	11	17	1	18	0
9¾	9	9	11	2	12	6	13	9	15	0	16	4	17	7	18	6
10	10	0	11	5	12	9	14	2	15	5	16	9	18	0	18	11
10¼	10	3	11	8	13	1	14	6	15	10	17	2	18	5	19	5
10½	10	6	12	0	13	5	14	10	16	3	17	7	18	11	19	10
10¾	10	9	12	3	13	9	15	2	16	8	18	8	19	4	20	4
11	11	0	12	6	14	1	15	7	17	0	18	5	19	9	20	9
11¼	11	3	12	10	14	5	16	0	17	5	18	10	20	2	21	3
11½	11	6	13	1	14	9	16	4	17	10	19	3	20	7	21	9
11¾	11	9	13	5	15	0	16	8	18	3	19	8	21	0	22	2
12	12	0	13	8	15	4	17	0	18	7	20	1	21	7	22	8

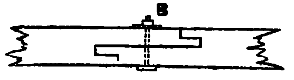
CARPENTRY.

Hints for the formation of Joints, and the Scantlings for various Bearings.

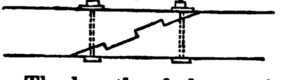
When the timber that can be obtained is not of sufficient length to stretch to the required bearing, it is necessary to joint the pieces together by bolts, straps, pins, &c., and the following instructions will give some of the methods to be employed. The operation is called *scarfing.*

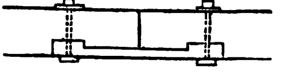
The figures A and B show the method to be employed in scarfing together the lengths of lintels, plates, and ties, the bolts, shown by dotted lines, are only necessary where it is necessary to obtain great strength, and in this, as in all cases, should be described to be of wrought iron, with proper heads, screws, nuts, washers, and plates.





The figures C D are usually employed for lengthening beams, bressummers, and the like.

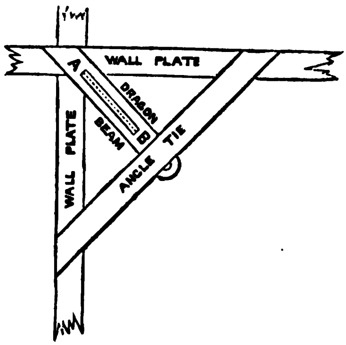


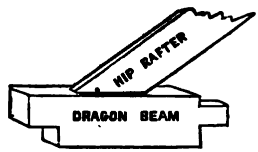


The length of the scarf should be drawn out according to the strain and size of the timber. It is usual, however, in fir, to make it four times the depth of the timber. The work should be very carefully done, as, if the joints are not precisely equal, there is an unequal strain on the parts

of the stuff, producing results nearly as disastrous as that which the mason calls flush bedding.

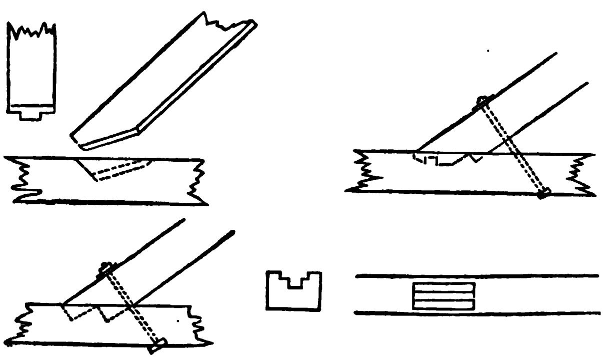
Wall plates are frequently framed together at the angles to strengthen the construction, or sometimes to receive the hip rafter, as shown in the annexed diagrams.





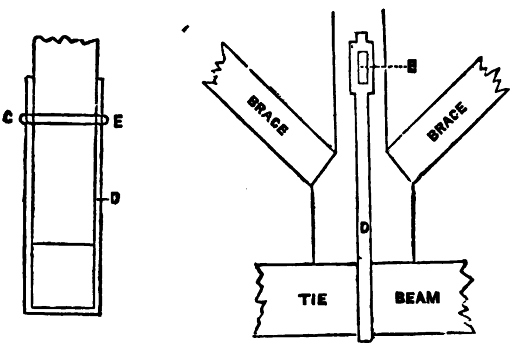
A B is the mortise for the tenon cut for the hip rafter.

The methods of cutting the mortises and tenons to principal and hip rafters, when they are received by the plates or ties, are thus:



The struts or braces to a king post of a roof are joggled into the king post, and their ends should be at right angles with the butt of the king. A strap is sometimes used to tighten the king post to the tie beam, but a bolt is more commonly employed.

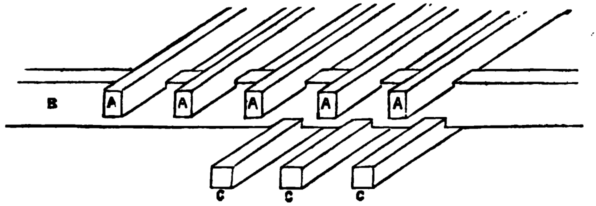
C gives a section of the beam and king post, showing the method of tightening and wedging the strap. D the strap, E the double wedge or key.



The scantlings of fir joists for single flooring should be as follows:

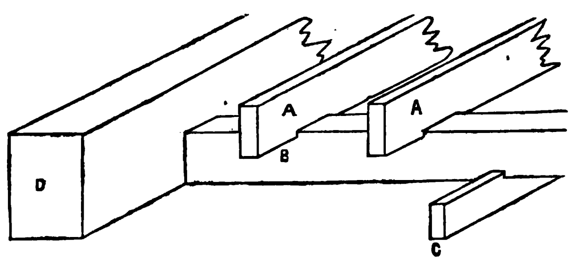
Length in feet.	Width in inches.	Depth in inches.
6	2½	5
9	2½	7
10	2½	7½
12	2½	8
14	2½	9
18	2½	12
20	3	12

The following is a diagram of a double floor :—



A A, the bridging joists; B, the binding joists; C C, the ceiling joists. The binding joists are the principal support of the floor, and go from wall to wall; the bridging joists are notched on to them, and carry the flooring boards upon them.

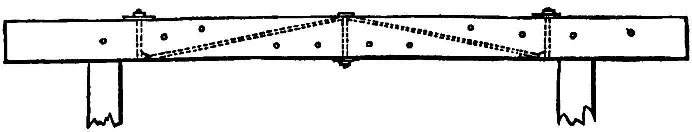
In the double framed floor the binding joists, instead of going from wall to wall, are framed into large girders, as shown below in sketch at D, and as before, B are the binding joists, A the bridging joists, C the ceiling joists.

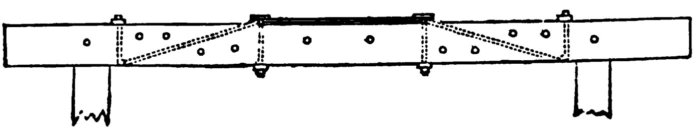


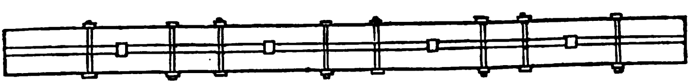
The girders are the principal supports, and should be of the following scantlings.

Girders of	10 ft. bearing	should be	9 in. deep,	7 in. wide.
„	12 „	„	10 „	8 „
„	14 „	„	11 „	9 „
„	16 „	„	12 „	10 „
„	18 „	„	12 „	11 „
„	20 „	„	13 „	11 „
„	22 „	„	14 „	12 „
„	24 „	„	15 „	12 „
„	26 „	„	16 „	12 „
„	28 „	„	16 „	13 „
„	30 „	„	16 „	14 „

When the bearing exceeds 24 feet it is difficult to procure beams of sufficient depth. It is usual, therefore, to strengthen a less depth by one of the following contrivances, which converts the beam itself into a piece of framework, or truss, and prevents it from *sagging*, as it is called, or bending.







Binding joists of the length of—

6 feet	should be	6 inches	deep,	4 inches	wide.
8	"	7	"	4½	"
10	"	8	"	5	"
12	"	9	"	5½	"
14	"	10	"	6	"
16	"	11	"	6½	"
18	"	12	"	7	"
20	"	13	"	7½	"

Ceiling joists of the length of—

4 feet	should be	2½ inches	deep,	1½ inches	wide.
6	"	3½	"	1½	"
8	"	4	"	2	"
10	"	5	"	2	"
12	"	5½	"	2½	"

IRON CONSTRUCTION.

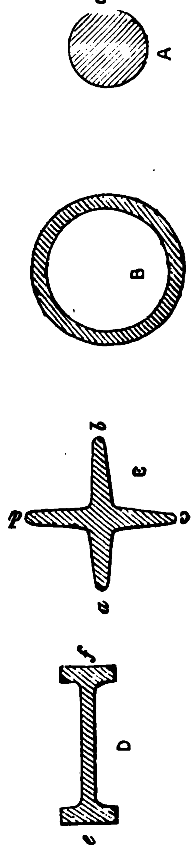
The most important application of iron to building purposes may be classed under two different heads, vertical supports and horizontal supports.

In the first, we have pillars, columns, standards, &c.; and in the second, we have girders, or beams, binders, lintels, &c. The constructive value of these depends on the qualities of iron to resist crushing and tensile forces.

A cylindrical form for vertical supports is one most commonly adopted. Thus, it has equal transverse strength in all directions, is readily moulded, the least offensive to the eye, and presents no angles nor awkward projections. If the metal is to be employed economically, and the greatest stiffness obtained with the least material, the sectional diameter is increased by casting the column hollow; if, on the other hand, it be desired to reduce its apparent size, the solid form is adopted. If transverse forces, to which the support will be exposed, act always in definite directions, an increased strength and stiffness may be obtained by giving the section greater diameter or breadth in such direction, and proportionally reducing the diameter in the other direction; and if these forces act definitely in two or more directions, increased width may similarly be given in such directions, without any total augmentation of metal. From these considerations we derive the four principal sectional forms for these members, as shown fig. 1, viz.: the solid and the hollow cylindrical, A and B; the cruciform, C, and the double-flanged, D. The cruciform is adapted for cases in which the forces may be expected to act at right angles

to each other in the directions $a\ b$ and $c\ d$; or practically

Fig. 1.



this form may be substituted for the cylindrical if more convenient for applying other parts of the construction, or otherwise preferable. The double-flanged, D, is especially designed for forces acting in one direction only, as $e\ f$, as when applied in corresponding pairs of standards to support a roof, &c. Fig. 2 shows another section, combining a hollow cylindrical column with feathers, ribs, or flanges projecting from it. Considerable strength is thus obtained, and the general appearance of the casting is agreeable to the eye. In fig. 3 a similar but differently proportioned figure is presented; the feathers in this section are of slight projection, but very wide, so that an octangular outline is presented. The projections or feathers are here to be regarded as expedients for producing lines in the elevation, rather than as aids to the rigidity of the column. The columns employed throughout the Exhibition building in Hyde Park, were similar in form to this section. Of the six sections here given, C and D are usually termed standards, in distinction from columns A B and E F.

Fig. 2.

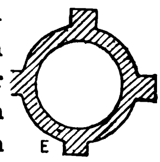
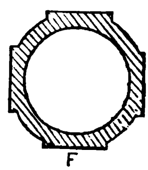


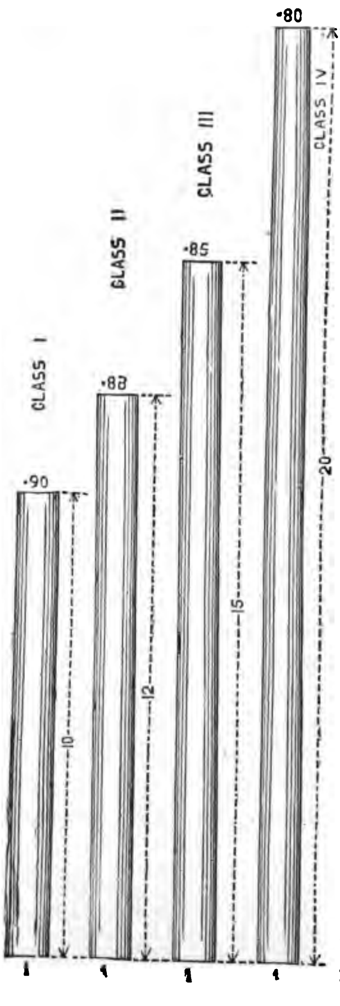
Fig. 3.



The weight required to crush cast iron tried in the form of cubes of one inch, varies considerably, 26 tons being about the lowest, and 31 tons the highest. By some experiments, however, a weight of 64½ tons per square inch of section has been found necessary to crush particular samples of this metal.* The practical effect of weights acting vertically upon cast iron columns, standards, &c., in deflecting them laterally from the vertical form, has not been observed or recorded to an extent which admits of general deductions. To attain the maximum strength with a given quantity of metal, however, there are certain limits of the proportion of the diameter to the length and to the thickness of metal, the observance of which will in all, or nearly all, cases, secure cast iron vertical supports equal to any weight which can be practically put upon them. And although the rules we are about to give for determining these limits may have the appearance of empiricism, yet being derived from actual experience, they may claim equal validity with formulæ which are usually based upon reductions from actual experiment, frequently depending for their correctness on an unwarranted comparison of small with great masses. For the purpose of facilitating the application of our rules to the several classes of buildings for supporting the loaded floors of which columns may be required, we recognise 4 classes, each admitting a different proportion of diameter to length. Class I. comprehends the heaviest description of work, such as that to which columns are subject in factories where massive materials are wrought,

* The most recent and elaborate experiments on Iron were those performed by the Royal Commission, "appointed to inquire into the application of Iron to Railway Structures." The principal results of these experiments will be found in a quarto work, "Iron applied to Railway Structures," with twelve plates, published by Atchley and Co.

Fig. 4.



powerful machinery erected, and concussions have to be provided for. For this class the limit of length is 10 times the diameter at the base. See Class I., fig. 4. In Class II. are included buildings where lighter factory labour is performed, and storehouses for heavy stores. In this class the length should not exceed 13 times the base diameter. See Class II., fig. 4. Class III. provides for lighter storehouses and manufactories, buildings for public resort, &c., and has a limit of length 15 times the diameter. See Class III., fig. 4. Class IV. includes dwelling houses, and all the less weighted structures, and admits a length of 20 times the base diameter. See Class IV., fig. 4. The same rate of taper or diminution, viz., 1 in 10, applies to all these classes. The thickness of metal in Class I.

may be from ⅛ to 1-12th of the base diameter; in Class II. from 1-12th to 1-16th; in Class III. from 1-16th to 1-20th; and in Class IV. from 1-20th to 1-24th. Thus, by way of examples, let the initial base diameter be one foot; Class I. columns will then not exceed 10 feet in length, according to circumstances, from 1 to 1⅛ inch metal. Class II. will not exceed 12 feet in length, and may have ¾ to 1 inch metal. Class III. may be 15 feet in length, and from 6-10ths to ¾ inch metal; and Class IV. should not exceed 20 feet in length with a thickness from ½ to ⅝ of an inch. Special circumstances, however, frequently affect the case, and must have full consideration before deciding on the dimensions. If an error be after all committed let it be a *safe* one; waste a few pence, or even pounds, in cast iron, rather than endanger an entire building, and risk destruction of life.

The following are the formulæ given by Eaton Hodgkinson for solid and hollow cylindrical columns:—

Solid cylinders of *cast iron*, with both ends rounded, and the length of the pillars being below thirty times their diameters,

$$W = 14{\cdot}9 \frac{D^{3 \cdot 76}}{L^{1 \cdot 7}}$$

wnere $W =$ breaking weight in tons, $L =$ length of column in feet, $D =$ diameter of column in inches.

Solid cylinders of *wrought iron*, with both ends rounded, and the length of the pillars being below thirty times their diameters,

$$W = 42{\cdot}8 \frac{D^{1 \cdot 76}}{L^{1 \cdot 7}}$$

where $W =$ breaking weight in tons, $L =$ length of columns in feet, and $D =$ diameter of column in inches.

These two formulæ are commonly applied, the *safe load*

being taken at $\frac{1}{4}$ of the breaking load, when the columns are firmly fixed. For irregular fixing, the safe load is taken at one-tenth of the breaking weight.

Hollow uniform cylindrical pillars of cast iron, with both ends flat, and firmly fixed,

$$W = 44{\cdot}34\frac{D^{3\cdot55} - d^{3\cdot55}}{L^{1\cdot7}}$$

where $W =$ breaking weight, $D =$ exterior diameter in inches, $d =$ interior diameter in inches, and $L =$ the length of the column in feet. Safe load as above; and it is also not unusual to restrict the practical load to two tons per square inch of metal.

Solid uniform cylindrical columns of wrought iron, both ends flat and firmly fixed, the length being under thirty times the diameter,

$$W = 133{\cdot}75\frac{D^{3\cdot55}}{L^{2}}$$

where $W =$ breaking weight, $D =$ the diameter of the column in inches, and $L =$ the length of the column in feet. Safe load one-quarter of breaking load.

CAST-IRON GIRDERS.

The formula for the strength of iron girders is,

$$W = \frac{a \times d \times C}{l}$$

where $W =$ the breaking weight in the centre;
$a =$ the sectional area of the bottom flange in square inches;
$d =$ the depth of the girder in inches;
$l =$ the length of span, or opening, in inches.
and $C =$ the constant of breaking weight.

For girders generally the breaking weight is taken in tons, and corresponding with this, the constant of breaking weight in the centre for cast-iron girders is taken at 25, when cast after the pattern or model determined by Mr. Eaton Hodgkinson, in which the sectional area of the top flange is made equal to one-sixth of the area of the bottom flange. This proportion *exactly* between the two flanges is not commonly adopted, but the form is so analogous that the constant 25 given above is almost universally adopted.

Referring now to a practical example, we will take a case of a girder for a span of 30 feet, or 360 inches. The best and most economical proportion between the span and the depth of the beam is generally considered to be one-twelfth of the span; the maximum working load of all descriptions, and uniformly distributed over the length of the beam, we shall take at $\frac{1}{2}$ a ton per foot lineal of opening, equal to $\frac{1}{4}$ of a ton when the load is considered as collected at the centre; we shall take 6 times the working load for the breaking weight of cast iron, and $\frac{1}{4} \times 6 = 1\frac{1}{2}$, which, multiplied by the span of 30 feet, will give 45 tons for W, the breaking weight. We might, of course, at once take 50 as the constant, and apply it to the uniformly distributed load; but it is so customary in practice to adopt the former plan of calculation, and it is always so unsafe to endeavour to carry a multitude of constants and methods for doing the same thing, that we shall make no further observations on the subject at present.

We have now the span, the breaking weight, the depth of the girder, and the constant, and we next require the area of the bottom flange, which we shall obtain by means of the following formula:—

$$\frac{W \times L}{d \times C} = a, \text{ or } \frac{W \times L}{d \times 25} = a,$$

in which a = the area of the bottom flange of the girder;

l = the length of span, or opening, in inches

d = the depth of the beam in inches;

and C or 25 = the constant adopted for cast-iron girders.

The above formula, converted into figures for this example, will give,

$$\frac{45 \times 360}{30 \times 25} = 21 \cdot 6$$ square inches of sectional area for the bottom flange.

If we take the thickness of the bottom flange at 1½ inches we shall have 14·4, or, say, 14½ inches for the width of the beam.

There would be nothing "unpractical" in taking the thickness at 2 inches and the width of the beam at 11 inches, which would give us 22 square inches of sectional area for the bottom flange.

The width is always optional, and must be determined more or less by the liability to flexure to which the beam is exposed, and the thickness of the bottom flange must necessarily depend on the width of the beam; in the above, where we have taken 14½ inches for the width of the beam, the width is one-half the depth.

The width of the beam at the centre and the thickness of the flange, which, for cast-iron girders, must be the same throughout the length, are, of course, all important; it is, however, necessary to remember that, at the bearings, the width of the flange may be advantageously reduced to two-thirds of the width in the centre of the beam.

The depth at the bearings may also be made two-thirds of the depth at the centre, and generally the length of the bearing may also be two-thirds of the depth at the centre. In the example before us, therefore, the *depth* at the bear-

ings will be 20 inches, and the length of bearing will also be 20 inches.

As another example, to see how these general rules work, we will take a 40-feet opening, which will give us 40 inches in depth; the working load we shall take at $\frac{3}{4}$ tons per foot run for each girder, or $\frac{3}{8}$ ton per foot run for each girder with the load collected at centre of the beam, which, multiplied by 6 times the working load for the breaking weight of cast iron, gives $2\frac{1}{4}$ tons, and multiplied by 40, the span, will give 90 tons; then,

$$a = \frac{W \times l}{d \times 25}$$

will become,

$\frac{90 \times 480}{40 \times 25} = 43{\cdot}2$ square inches of sectional area in bottom flange.

If we now put the thickness of the flange at $1\frac{3}{4}$ inches, we shall have width of the bottom flange $= 24{\cdot}7$ at the centre of the beam, two-thirds of which, $= 16{\cdot}46$ inches, will be the *width* of the bottom flange at the bearings; two-thirds of the depth of girder, 40 inches, $= 26{\cdot}6 =$ the depth of girder at the bearings, $=$ also to the length of the bearings.

In getting out the dimensions of cast-iron girders, we have always to remember that the greater the casting, the more liable we are to imperfections.

As regards the sectional area of the top flange, we shall have merely to take one-sixth of the area of the bottom flange, where this proportion is adopted; but in practice, it is more commonly made one-quarter; where the girder is loaded on the top flange, take one-third of the sectional area of the bottom flange; the top flange is made of the same breadth throughout.

The thickness of the web is made a little less than that of the bottom flange at bottom, and somewhat less than that of the top flange at top. It might be made very much less than this, but for the defect likely to arise from unequal cooling in portions of unequal thickness in the same casting and in contact with each other.

As already observed, the transverse strength of a cast-iron girder is calculated by the formula,

$$W = \frac{a \times d \times C}{l}$$

where W = to breaking weight in tons, when the constant is taken in the same unit;

a = the sectional area of the bottom flange in square inches;

d = the depth of the girder in inches;

C = the constant, taken at 25 tons for cast-iron girders;

and l = the length of the span or opening.

In the example last given, for 40 feet span, 40 inches depth, and 43·2 square inches of sectional area in the bottom flange, we shall have,

$$\frac{43{\cdot}2 \times 40 \times 25}{480} = 90 \text{ tons breaking weight.}$$

We may now observe that, in any case where we have the breaking weight of a girder or model, we may deduct a constant for such pattern from the following formula:—

$$C = \frac{W \times l}{a \times d}$$

where C = the constant required, W = the breaking weight, $\Big\}$ in tons, cwts., or lbs., as may be desirable.

l = the length of opening in inches;

d = the depth in inches;

and a = the sectional area of the top or bottom flange, accordingly as the constant C is intended to be applied; that is to say, that the constant C is equal to

$$\frac{\text{the breaking weight} \times \text{the length}}{\text{the sectional area} \times \text{the depth}};$$

Similarly we have the following:—

$$S = \frac{l \times W}{4 \times a \times d}$$

where S = the breaking strain per square inch } in Tons,
W = the breaking weight } cwts. or lbs.
l = the length in inches;
d = the depth in inches;
a = the sectional area in square inches.

S may be the strain per square inch, either in the top or bottom flange, or for the whole of the beam.

Also,

$$4s = \frac{l \times W}{a \times d}$$

the notations being as above.

In getting out the design of any cast iron work, it is always very requisite to study how the patterns will come out of the mould; this is rendered easier by slightly and gradually reducing the thickness of that part of the pattern which is most deeply sunk in the loam, and also by rounding all interior angles, and getting rid of all sharp corners.

Cast Iron Cantilevers.—To find the area of the flange in square inches to support a load at the extremity or free end, we have the following:—

$$a = \frac{W \times l}{6 \times d}$$

If the load is *uniformly distributed*, then,

$$a = \frac{W \times l}{12 \times d}$$

For warehouses designed only to hold the lighter descriptions of goods, or for public buildings generally, where a number of people may accumulate, 1½ cwt. per square foot of flooring is sufficient to provide for, including the weight of materials.

For warehouses calculated to hold heavy goods, 2½ cwts. per square foot of flooring will have to be provided for.

Wrought Iron Girders.—The sectional area of the bottom flange of wrought iron girders may be calculated from the following formula, which is the same as that for cast iron, with the exception that we shall use a different constant.

$$a = \frac{W \times l}{74{\cdot}4 \times d}$$

where a = sectional area in square inches of bottom flange;
l = the length of span or opening in inches;
d = the depth of the girder in inches;
W = the breaking weight in tons.

On the subject of wrought iron girders applied to public buildings and factories, Dr. Fairbairn has observed, "Another feature in the use of this material is the scope which it gives of an extension of space to any distance commensurate with the convenience of the establishment, or the taste of the architect or engineer. Most of the improved cotton mills are from 60 to 65 feet in width, with two or three rows of columns, at distances of 15 to 16 feet across the mill, and from 9 to 10 feet in the direction of its length. These columns present serious obstructions to the convenient arangement and free working of the machinery; but they

cannot well be avoided where cast iron columns are used. By the employment of wrought iron they quickly vanish, as one row of columns in the middle, with only two beams in width, not only meets the objection, but removes all doubts as to the security of the structure.

In these constructions, however, it must be borne in mind, that an increase of space is attended with considerable increase of expense, not only as regards the increased weight of the girders, but also as relates to the depth of the flooring, which amounts to a waste of height in the building. When, however, this is not the most important consideration, fire-proof mills may be built, upwards of 60 feet in width, without the introduction of a single column, or any obstruction whatever.

In large public buildings this may be effected with the greatest facility, and the beams constructed so as to carry some four tons to the square yard.

In a building, however, with a central column, and with 30 feet bearings, we may make the beams 22 inches deep, (one-sixteenth of the span) five-sixteenths inch thick, and angle iron three-eighths inch thick, riveted on both sides at the bottom of the plate, and angle iron $\frac{1}{2}$ inch thick at the top, the width over the top being $7\frac{1}{4}$ inches, and the bottom $5\frac{1}{2}$ inches.

The breaking weight of such a beam, taking the constant at 75, would be as follows:—

$$W = \frac{a \times d \times C}{l}$$

or,

$\frac{75 \times 6 \times 22}{360} = 27{\cdot}5$ tons at the centre of the girder, or 55 tons uniformly distributed over the surface.

And,

$$a = \frac{W \times l}{75 \times d}$$

will become,

$\frac{27 \cdot 5 \times 360}{75 \times 22} = 6$ square inches of sectional area in bottom flange.

By the formula,

$$S = \frac{l \times W}{4 \times a \times d}$$

we have,

$\frac{27 \cdot 5 \times 360}{4 \times 6 \times 22} = 18 \cdot 75$ tons the breaking strain per square inch, which is one-fourth of the constant 75.

This quantity of 18·75 tons per square inch, certainly appears but a small strain to destroy wrought iron girders well built and of good materials. Much depends on the design of the details, as covers, angle irons, butt plates, and covering angle irons, &c.

Wrought iron girders of even larger dimensions than the above are now being rolled by the iron masters in one piece; on these the breaking strain per square inch should not be less than 20 tons, which would give us a constant = 80 tons. They would of course be more costly, but this ought to be more than compensated for in the diminished quantity of material.

If, instead of paying for wrought iron girders *by the ton*, we were to pay for them by their strength, it does not appear impossible that we should obtain very different materials to those at present supplied. We are disposed to think this remark applies more particularly to girders of moderate dimensions; for the large plate girders used for heavy bridges, we are always more or less under restriction, on account of the riveting work.

BRIDGE PLATE GIRDERS.—The large dimensions which these obtain, render a larger amount of calculations requisite than for flooring girders, or for those of small dimensions.

To find the sectional area in the centre, for either flange of a wrought iron plate girder supported at both ends, and to carry a load collected at the centre:

Divide by 2 the assumed uniformly distributed load, including an assumed weight for the structure, and for this weight in tons put W; then take either of the following formulæ:—

$$a = \frac{W \times l}{74{\cdot}4\, d}$$

or,

$$a = \frac{W \times l}{4 \times s \times d}$$

in which, W = breaking weight in tons at centre;

l = the length in feet, d = the depth in feet, or *both* taken in inches.

74·4 = the constant;

s = the safe strain per square inch of metal,

and a = the sectional area in square inches.

For the bottom flange this area is exclusive of the rivets.

To find the area in square inches for the flanges at any point of their length, the girder being, as before, supported at both ends, we have,

$$a = \frac{W \times x}{2 \times s \times d}$$

in which a = the sectional area in square inches, exclusive of rivets for bottom flange;

W = the weight in tons at the centre;

x = the length in feet from the nearest point of support;

d = the depth of the girder in feet;

s = the safe resistance in tons per sq. in. of metal.

To find the area of the web, we have the following formula:—

$$a = \frac{W}{25}$$

in which W = load at centre in tons;
a = the sectional area in square inches;
and s = the safe shearing resistance in tons per square inch of metal.*

EXPERIMENTAL STRENGTH OF PLATE IRON.—The experiments of Mr. David Kirkaldy† prove how very much the strength of iron varies, as may be observed from the table of breaking strains on p. 108.

Of riveted iron girders, it may be observed generally, that the holes drilled for the rivets are of course so much material, the strength of which is abstracted from the bottom flange, under tension, which is not the case in the top flange, under compression.

The strength of wrought iron girders depends not only on the strength of the material, but on the workmanship, and on the practical skill with which the details of angle irons, butt plates, T irons, covers, and covering angle irons, are designed.

When the sectional area of the top is made otherwise equal to that of the bottom flange, it is often increased by the addition of strong angle irons, riveted underneath, along the exterior edges of the flange.

* For a very extensive set of rules for wrought iron girders generally, see Mr. Campin's "Engineer's Pocket Remembrancer."

† Results of an experimental inquiry into the comparative tensile strength and other properties of various kinds of wrought iron and steel, by David Kirkaldy.

Tensile Breaking-weights in tons per square inch of original areas.

Areas of the Specimens. Original square inch.	Fractured square inch.	Mean of all on various brands. lengthways and crossways.	Highest applied lengthways.	Lowest applied crossways.	Mean applied lengthways.	Mean applied crossways.	Number of Experiments.
·750	·605	25·3	27·9	...	...	...	...
·750	·669	...	...	23·6	...	...	...
...	...	...	...	...	26·08	24·5	4
...	...	25·2	...	...	...	...	...
·750	·649	...	27·3	...	...	...	...
·750	·669	...	...	22·1	...	...	..
...	...	24·1	...	...	26·1	...	3
·623	·524	...	27·2	...	...	24·1	6
·776	·702	...	...	21·1	...	...	...
...	...	22·9	...	...	25·4	22·8	6
·624	·477	...	25·8	...	...	...	...
·624	·548	...	...	21·1	...	...	...
...	...	22·9	...	...	23·4	22·5	5
·700	·628	...	25·1	...	...	...	...
·930	·854	...	...	20·4	...	...	...
...	...	20·2	...	...	24·0	21·8	6
·775	·693	...	25·8	...	...	...	...
·988	·959	...	...	16·6	...	...	...
...	·648	23·2	...	...	23·8	...	18
·826	·784	...	25·7	...	..	18·6	14
·816	...	...	...	20·6	...	...	...
...	...	22·1	...	...	24·4	22·0	6
·651	·554	...	25·8	...	...	...	...
·706	·671	...	...	18·2	23·9	20·4	10

Tensile Breaking-weights of Angle Iron per square inch of original areas.

Size. Inches.	Highest Tons.	Lowest Tons.	Mean Tons.	Contraction of Fractured areas mean per cent.
Nine-sixteenths . .	28·4	26·2	27·3	20·9
Five-eighths . . .	26·	23·9	25·	15·0
Five-eighths . . .	25·2	23·8	24·4	13·7
Nine-sixteenths . .	25·5	24·5	25·	15·4
Five-eighths . . .	25·8	24·1	25·	14·0
		BAR IRON.		
Rolled, 1 inch square	27·8	26·4	27·	
Forged, from 1¼ inch	30·3	28·9	29·6	
Rolled, 1 inch round	29·3	26·2	27·9	

SEWERS.

A WELL-proportioned egg-shaped sewer is obtained by the following proportions:—

Assume the diameter, and describe the curves with the following radii:—

	Constant Tabular Multipliers.
Major axis, or depth of sewer	= diameter × 1·5833
Radius at the crown of the arch	= diameter × 0·4166
Radius of upper-side arch	= diameter × 0·8338
Radius of lower-side arch	= diameter × 1·3611
Radius of invert	= diameter × 0·3055

The centres from which the curves are described are, of course, in the major axis for the crown of the arch and for the invert; and for the side arches, the centres are on the diameter, or the diameter produced.

The egg-shaped sewer contains the least quantity of material, and is also the strongest, and is particularly applicable to slippery soils.

All junctions and all changes of direction should be curvilinear, no right angles being on any account permissible, and the greater the radius of curve the better; the radius of curvature should never be less than 10 feet.

In all drains running into sewers, the junction should be considerably above the invert. Careful attention is required to the subject of ventilation, particularly in case of any great difference of level, as otherwise the atmosphere of a higher district will be poisoned by the foul air from the lower levels.

HYDRAULICS.

SETTING-UP A NOTCHED-BOARD OVERFALL.

When, to ascertain correctly the quantities of water passing down a stream at different periods of the year, it is considered necessary to set up a notched-board overfall, some attention is required as to the manner in which it is done, more particularly with a stream of perhaps 8 or 10 feet in width.

It should be set up at right angles across the stream. The centre of the notch should coincide with the centre of the current, and the board should be of sufficient length that the sides may be well buried into the banks of the stream, and of such depth that the lower edge may be sunk down into the bed of the water-course.

It is desirable to look for a run of the stream where the banks are straight and tolerably even, as also the bed of the stream itself; and if there be a spot where the banks widen out, so as to form a kind of basin, then such spot should be selected, if there be nothing particular to prevent it.

The notched board should consist of 2 or 3-inch planking, according to the width of the stream, carefully jointed and caulked, if necessary, to prevent any water leaking through. When of any length, it will require strong framing to prevent its bending under the weight of water accumulated behind it.

In this boarding a deep notch should be carefully cut, and the dimensions carefully ascertained; there should always be a certain number of whole feet, and without any fractions of feet.

The length of the notch should be of such proportions

that the overfall may constitute a complete bar across the stream, but not so small as to wire-draw the current.

The edges of the notch are to be carefully bevelled off at an angle of 45 degrees, and on the sides as well as along the sill.

At the back of the acute angle, along the sill and vertical sides, should be fastened a plate of iron, with edges coinciding with the bevelled sides of the notch, and so that the whole notch may be smooth and sharp. The particular object of applying the metal plate is to keep the edges of the notch clean and sharp for almost any length of time. If this precaution is neglected, it will be found that, after the winter and spring frosts and floods, the edges of the unprotected timber become so ragged and irregular as to interfere with the due contraction of the liquid vein, more particularly with low heads.

The depth of the whole of the planking must be sufficient to reach to the top of the banks, unless they happen to be very high, and down into the bed of the stream for the depth of a foot or more, according to the soundness of the earth, as clay, or loam, or gravel and sand: it is necessary to prevent leakage.

It takes some little trouble and requires some attention to get the notched board completely fixed across the stream. The overfall board having been constructed, and ready to be got in, narrow trenches are cut down the banks of the stream and across the bed to receive it. It will generally, however, be found advisable to have a small mound of clay or stiff loamy earth, tempered and worked, and ready at hand, before attempting to fix the dam in its place; so that immediately it is done the earth may be thrown in and worked down, in the fashion of puddle, before the stream dammed back has time to overflow the notch.

A rough kind of timber apron should also be in readiness to be fixed in the bed of the stream in front of and below the overfall, to receive the fall of water as it flows over the notch.

If this last precaution is neglected, the fall of water will tear up the bed of the stream and undermine the overfall, as soon as the first rains come on.

With regard to the level at which the sill of the notch must be fixed, the higher this is placed the better will *still water* be obtained to measure the heads from; but there are one or two conditions to be examined in reference to this subject. Where the stream runs along between steep banks, the sill of the overfall may be raised to a considerable height above the natural level of the surface of the water; but in meadow land, where the banks are comparatively shallow, if the sill is raised too high, the first heavy rains would cause the water to overflow the banks above the overfall. The level of the sill must therefore be established accordingly, and it is desirable in doing so to attend to the level of any road that may cross the stream at a little distance above the overfall. On the other hand, it is very requisite that the sill be sufficiently raised to prevent its being easily submerged, or *drowned*, by any increase of water in the stream.

A few feet above the overfall, a square post must be driven into the bed of the watercourse, and in the centre of the current. This may be done before the overfall is got into its place; and immediately this is done and the level of the sill *settled*, a sharp, stiff feather-edged rule, some 2 feet long, divided into tenths and hundredths of a foot, should be securely nailed to the post, with the zero exactly level with the edge of the sill of the overfall. This must be done with the assistance of the spirit-level. The divi-

sions on the rule should be distinctly marked, in order that they may be easily read off from the banks of the stream.

By means of this rule, the heads of the water passing over the overfall are read off, minus, however, any head that may be due to the velocity of the stream in approaching the weir, and which must be taken into account, more particularly in rainy weather, when generally this velocity becomes considerable.

Where there are several of these overfalls to be gauged many times in the course of a day, it will be observed that every means must be taken to facilitate the reading off, and so that the calculations may be readily effected day by day.

In the tabular forms prepared for the purpose, remarks should always be made on the state of the weather.

The depths of water on the head of the post being measured, the formula for ascertaining the quantity of water flowing over is as follows:—

$$Q = 481{\cdot}8 \times C \times a\sqrt{h},$$

in which Q = the quantity in cubic feet discharged per minute;

a = the area in feet, or the length multiplied by

h = the height in feet of the fall, or the difference of level between the edge of the sill and still water;

and 481·8 a constant, to be multiplied by a coefficient, which varies under a great many circumstances, as will be seen from the following table:—

EXPERIMENTS

ON THE KENNET AND AVON CANAL.

Table showing the variations in the coefficient for different heads of water in overfalls, the head being measured to still water.

	Description of Overfalls.	Head in inches.	Co-efficient C.	481·8 × C.
No. 1.	Thin plate 3 feet long	1 to 3	·440	211·99
	„ „ „	3 „ 6	·402	193·68
No. 2.	„ 10 „	1 „ 3	·501	241·38
	„ „ „	3 „ 6	·435	209·58
	„ „ „	6 „ 9	·370	178·26
No. 3.	Plank 2 inches thick, with notch 3 feet long	1 „ 3	·342	164·77
	„ „ „	3 „ 6	·384	185·01
	„ „ „	6 „ 10	·406	195·61
No. 4.	Plank 2 inches thick, with notch 6 feet long	1 „ 3	·359	172·96
	„ „ „	3 „ 6	·396	190·79
	„ „ „	6 „ 9	·392	188·86
	„ „ „	9 „ 14	·358	172·48
No. 5.	Plank 2 inches thick, with notch 10 feet long	1 „ 3	·346	166·70
	„ „ „	3 „ 6	·397	191·47
	„ „ „	6 „ 9	·374	180·19
	„ „ „	9 „ 12	·336	161·88
No. 6.	Plank 2 inches thick, with notch 10 ft. long with wings	1 „ 2	·476	229·34
	„ „ „	4 „ 5	·442	212·95
No. 7.	Overfall with crest: 3 feet wide sloping 1 in 12, 3 feet long, like a weir......	1 „ 3	·342	164·77
	„ „ „	3 „ 6	·328	158·03
	„ „ „	6 „ 9	·311	149·84
No. 8.	Overfall with crest: 3 feet wide sloping 1 in 18, 3 feet long, like a weir......	1 „ 3	·362	174·41
	„ „ „	3 „ 6	·345	166·22
	„ „ „	6 „ 9	·332	159·96
No. 9.	The same sloping 1 in 18, 3 feet wide and 10 feet long	1 „ 4	·328	158·03
	„ „ „	4 „ 8	·350	168·63

	Description of Overfalls.	Head in inches.	Co-efficient C.	481·8 × C.
No. 10.	Overfall with level crest:			
	3 feet wide and 6 feet long ...	1 „ 3	·305	146·95
	„ „ „ ...	3 „ 6	·311	149·84
	„ „ „ ...	6 „ 9	·318	153·21
No. 11.	Overfall 6 feet long:			
	crest level 3 feet broad.........	3 „ 7	·330	158·99
	„ „ „	7 „ 12	·310	149·36
No. 12,	Overfall 10 feet long:			
	crest level 3 feet broad.........	1 „ 5	·306	147·42
	„ „ „	5 „ 8	·327	157·55
	„ „ „	8 „ 10	·313	150·80

When the water approaches the weir with any degree of appreciable velocity, so that the surface is no longer still water, but in fact a current, it will be necessary to ascertain the head due to the velocity, and add the head thus found to the measured head or depth of water at the spot above mentioned.

This occurs so often in gauging streams, when there is any considerable addition to the body of the stream, that it requires te be attended to.

The formula then becomes—

$$Q = 481{\cdot}8 \times C \times a\sqrt{h + h^1}$$

where Q=quantity in cubic feet discharged per minute;

a=the area;

h=the measured head;

h^1=the head due to the velocity of the approaching current;

and 481·8 the constant, to be multiplied by a coefficient, as above.

The Rain Gauge and Glass.—With a given diameter of rain gauge, and a given depth of rain to find the weight of the rain water, we have the following formula:—

$$D^2 \times {\cdot}7854 \times R \times {\cdot}577$$

in which D=the diameter in inches;

R=the depth of rain in inches;

and 0·7854 and 0·577 are constants.

With a given diameter of cylindrical glass, to find the depth that shall hold a given weight of water, we may take the following :—

$$\frac{W}{D^2 \times \cdot 4532}$$

in which W=weight of water in ounces, avoirdupois;
and D=the diameter of the glass in inches.

Flow of Water through long Pipes.—For general conditions in reference to water-pipes, the following formula may be used :—

$$V = 39{\cdot}49 \sqrt{D \times H}$$

in which V=the velocity in feet per minute;
D=the diameter of the pipe in feet;
and H=the fall in feet per mile;
and by,

$$Q = V \times D^2 \times \cdot 7854$$

in which Q=the quantity in cubic feet per minute·
V=the velocity, as above;
D=the diameter of pipe, as above.

This formula agrees very nearly with the following :—

$$V = 96\,(R\,S)^{\frac{1}{2}}$$

in which V=velocity in feet per second;
R=the mean hydraulic depth, which is equal to one-half of the radius of the pipe;
S=the inclination of the pipe, or the height of fall divided by the length.

Under the most favourable circumstances of *straight* pipes, &c., we may use the following :—

$$V = 41{\cdot}3 \sqrt{D \times H}$$

in which V=velocity in feet per minute;
D=diameter of pipe in feet;
H=the fall in feet per mile.

QUANTITIES AND ESTIMATING.

The practice for taking out quantities differs in the various parts of the British Islands. In London and the other large towns, by the rules of the various Institutes and Architectural Societies, an architect is forbidden to take out the quantities for his own work,—a very wise and necessary rule, because, if an architect is to be an impartial umpire between his employer and the contractor, it is certainly better that he should have no interest in the quantity of materials used, or their quality; also, although the price of taking out the quantities is an "indirect tax" on the price of the work, it is usual for the contractor to add the amount to the contract sum, and pay whoever has taken out the quantities, out of the sum received from his first instalment, certified to be due to him.

Now, as the architect has to give this certificate—and it is upon the production of this certificate that the contractor is paid—he (the architect) is descending at the first stage of the work from his neutral ground, and certifying for money that he will put in his own pocket in an indirect manner.

Other unpleasant, and indeed invidious, occurrences are also possible. The contractor is constantly finding out that "there is not so much filleting in the quantities as the building requires," or some other matter. Naturally,

if he is a man of business of the usual type, he does not mention the (to him) gratifying fact that many items are taken "full," that is to say, he is to be paid for a larger quantity of several kinds of articles, or quantities of workmanship than he will be required to use.

If an architect can steer through all these difficulties, and feel that he has done equal justice to all parties, he may then perhaps defy the Institute and all its rules,—but he had much better not.

In the small towns it is still the very general practice for the architect to take out his own quantities,—and perhaps it may be done there with greater impunity, as, society being in a smaller circle, there are greater safeguards against corruption on the one hand, and too sharp practice on the other.

In France, Belgium, Germany, and also, I think Italy, the architect is expected to take out his own quantities; but there he does it without an extra charge, and the quantity sheet is used as a specification.

The continental practice is for the architect to put his own prices upon his quantities and give his employer an estimate of the cost from them; these are furnished to the builder, or competing builders, and they send in their tenders as being the same, or so much per cent. below or above the amount given in by the architect.

As wherever the decimal system of weights and measures is used, all calculations are rendered much more facile than with our lumbering method of measuring every material in a different way, and every district having a different method of measuring every material, the work thrown upon the architect is not so arduous as it appears at first sight.

To return to our English system of estimation by quan-

tities. The reader is referred to the article on "Rules for the Measurement of Work," in which the usual method of procedure is fully laid down, in an exhaustive manner, and detailed for the separate trades.

Professor Donaldson, in his work on Specifications, lays down some extremely valuable rules for obtaining an approximate idea of the cost of a building; and, as they will be apropos in this place, I shall lay his experience under contribution, slightly altering them to that which has occurred to myself in my own practice.

"Measure from the bottom of the brick or stone footings of the walls to half way up the roof, and this will give the dimension of the height.

"This should be multiplied by the superficial area including all the walls.

"The cubical contents so produced are multiplied by the sum per foot cube, which it is supposed would be pro per for the class of building to be estimated.

"(Add also for the chimneys or other special work, which cannot be fairly cubed with the rest of the building)."

"The amount will be the probable cost, exclusive of the fittings, which will of course vary according to the taste and requirements of the occupier."

A third-rate dwelling house in London, or Country Lodge . .	5d. to 6d. per ft.
A second-rate " "	7d. "
A first-rate " "	8d. to 11d. "

(according to the construction and method of finishing).

A nobleman's house, or club house, with stone elevation, and first-class internal finishings . . .	1s. to 1s. 3d. "

"The above are calculated for town houses, but for country houses, the distance from a railway station, the distance of walling materials, and other causes, will make additions or deductions to the above prices.

"An average price for the usual kind of parsonage house, including offices, will be 6d. per foot.

"Domestic offices and stables may be taken separately at 4d. to 5d. per foot, according to their style of finishing.

"Workhouses, hospitals, warehouses, and such like buildings, having large internal spaces, and few divisions, and with architecture of a simple and substantial character, may be taken at 4d. to 6d. per foot cube.

"Lunatic asylums, and prisons requiring more special provisions and greater subdivisions, would be somewhat more expensive than the last-named class.

"Simple meeting halls, and large rooms for assemblies, may be taken at from 5d. to 6d. per foot cube, but an additional sum must be added if one part is more ornamental than another, so as to form 'the façade.'"

A simple village church may be taken at from 5d. to 6d. adding for the chancel fittings; or the cost may be calculated very nearly, in most cases, by taking the sitting accommodation at from £5 to £6 each person, which will include a moderate chancel, with extra for the fittings in the chancel.

Church towers must be taken separately, and if above 12 feet square, and with stone spire, may be taken at about £10 per foot in height, up to 80 feet, beyond that, as the tower will increase in diameter and probable costliness of finish, a proportionate amount must be calculated for every foot in height, bearing in mind that the greater the height the more expensive is every operation, construction, working, setting, scaffolding, &c.

MEMORANDA OF QUANTITIES AND METHODS OF VALUATION AND MEASURING VARIOUS ARTIFICERS' WORKS.

EXCAVATOR AND DIGGER.

In taking the digging of foundations, allow about six inches on each side for room to work in, except when the footings are very deep, in which case allow nine inches on each side; where concrete is used, measure only the net width of the concrete foundation.

Reduce the whole dimensions when taken to the yard cube of 27 feet on one single load, and two cubic yards equal one double load. Also state whether for digging, wheeling, and spreading or throwing away, or carting to a distance.

In loose ground, a man will throw up about ten cubic yards per day, but in hard, or gravelly soil, where picking is necessary, from four to six yards, according to the hardness of the ground.

Wheeling is estimated at the run of twenty yards. A gang of three men, two for filling and one for wheeling, will remove about thirty yards a day to this distance, and the labour of removing earth may be calculated according to distance, allowing three men to the first run, and an additional man to every thirty yards of distance.

The following are the average rates of the alteration in bulk of various soils when excavated and carried into embankment.

Clays—About one-tenth of original bulk in excavation.

Gravels—About one-twelfth of original bulk in excavation.

Sand—About the same bulk.

Chalk—A slight increase, in proportion to the size of the fragments, and their hardness.

Rock—Increases from about one-half of the original bulk, according to the size of the fragments.

SIZE AND WEIGHT OF VARIOUS SUBSTANCES.

		Length. FT.	IN.	Breadth. FT.	IN.	Thickness. FT.	IN.	Weight. LBS.	OZ.
Stock bricks	each	0	8¾	0	4½	0	2½	5	0*
Paving do.	”	0	9	0	4½	0	1¾	4	0
Dutch clinkers	”	0	6¼	0	3	0	1½	1	8
12 inch paving tiles	”	0	11¾	0	11¾	0	1½	13	0
10 inch do.	”	0	9¾	0	9¾	0	1	8	9
Pan tiles	”	1	1½	0	9½	0	0½	5	4
Plain tiles	”	0	10½	0	6½	0	0⅝	2	5
Pantile laths, per 10 ft. bundle		120	0	0	1½	0	1	4	6
Do. do. 12 ft. (A bundle contains 12 laths.)		144	0	0	1½	0	1	5	0
Plain tile laths, per bund. (Thirty bundles of laths make a load.)		500	0	0	1	0	0¼	3	0

BRICKLAYER.

A rod of brickwork measures 16ft. 6in. by 16ft. 6in., or 272ft. 3in. superficial, 1½ brick thick, which is the standard thickness, or 306 cubic feet, or 11⅓ cubic yards.

A set of dimensions brought to one thickness of 1½ brick work, is called *reduced.*

A rod of brickwork laid four courses to a foot in height, requires 4353 stock bricks.

* These weights are taken supposing the articles to be dry—not *dried*, but in their normal state or average condition.

Ditto, laid to 11½ inch gauge, requires 4533 stock bricks.

A foot of *reduced* brickwork requires 16 bricks.

The usual allowance for a rod of brickwork in a building, is 4300 stocks, as there are always some deductions in timber, flues, &c., but this allows for no waste.

5370 stocks, in a rod laid dry.

4900, in walls and circular cesspools.

A rod of brickwork laid four courses to gauge 12 inches, contains 235 feet cube of bricks, and 71 feet cube of mortar, and the average weight is about fifteen tons.

In a rod of brickwork there are 1½ cubic yards of chalk lime, and three loads of sand, or one yard of stone lime, and 3½ loads of sand, or 36 bushels of cement, and 36 bushels of sharp sand.

A cubic yard of mortar requires nine bushels of lime and one load of sand.

The proportion of mortar and cement when made up to their mixed state, is as two to three.

Facing requires 7 bricks per foot superficial.

Gauged arches 10 ditto ditto

Bricknogging per yard superficial, requires 30 bricks on edge, or 45 laid flat.

PAVING.

Stock bricks, laid flat, per yard,			36	required.
Ditto	on edge	„	52	„
Paving bricks, laid flat		„	36	„
Ditto	on edge	„	82	„
Dutch clinkers		„	140	„
12-inch paving tiles, laid flat			9	„
10-inch	„	„	13	„

SLATER'S WORK.

Slating is measured superficially, and charged per square of 100 feet.

In measuring, allow for the eaves whatever the bottom course measures, and for the hips and valleys measure their length by 12 inches, viz., 6 inches on each side. Measure also the length of all angles, as chimneys, dormers, &c., by six inches wide, as a fair allowance for cutting and waste.

For circular slating (as to the apse of a church) allow one-third extra.

TABLE OF MATERIAL AND LABOUR.

AVERAGE SIZE OF SLATES.	FT.	IN.		FT.	IN.	Average gauge when laid. IN.	1,200 will cover squares.	Weight per 1,000 of 1,200 in tons.	Number in one square.	Nails in one sq.: Iron, cast or wrought, per 100.	Nails in one sq.: Copper, at per lb. LBS.
Double	1	1	×	0	6	$5\frac{1}{2}$	$2\frac{1}{2}$	$\frac{3}{4}$	480	480	5
Ladies	1	3	×	0	8	7	$4\frac{1}{2}$	$1\frac{1}{4}$	280	280	3
Countesses	1	8	×	0	10	10	$7\frac{1}{2}$	2	160	320	$3\frac{3}{4}$
Duchesses	2	0	×	1	0	11	10	3	127	254	$2\frac{3}{4}$
Imperials	2	6	×	2	0		A ton will cover $2\frac{1}{4}$ to $2\frac{1}{2}$				
Rags & Queens	3	0	×	2	0						
Westmoreland, various sizes							$2\frac{1}{4}$				

TILING.

Pantiles per square, 12-inch gauge, 150 required.
" " 11 " 164 "
" " 10 " 180 "

A square of pantiling requires one bundle of laths, and $1\frac{1}{4}$ hundred of 6d. nails.

Plain tiles per square,		4-inch gauge,		600 required.	
,,	,,	$3\frac{1}{2}$	,,	700	,,
,,	,,	3	,,	800	,,
,,	,,	laid flat		210	,,

A square of plain tiling requires one bundle of laths and nails, one peck of tile pins, and three hods of mortar.

CARPENTER'S AND JOINER'S WORK.

Roofs, floors, partitions, &c., may be measured by two methods, one by taking the superficial contents at per square of 100 feet for labour and nails, and afterwards taking the cube contents of the timber without labour; or by measuring only the cube contents of the timber, as cube fir and labour, framed, &c. The latter method is preferable in most instances, and should be taken as follows:—

Cube fir, or oak, in ground joists, bonds, lintels, plates, &c., labour and nails included.

Ditto, framed in roofs, partitions, naked floors, &c., labour and nails included.

Ditto, ditto, truss framed, ditto.

Ditto, ditto, wrought and framed, ditto.

Ditto, ditto, wrought, framed, and rebated, ditto.

Ditto, wrought, framed, rebated, and beaded, ditto.

Ditto, in door cases.

Take the extreme dimensions of all timber. The openings for chimneys, &c., should not be deducted, as the trouble of trimming is fully equal to running the timbers through. Herring bone strutting, per foot run extra.

Furrings to ceilings, quarter partitions, battenings to walls, &c., are measured by the square, including labour

and nails; mention the thickness of deals, describe battening, whether framed or nailed, and if plugged or with horizontal backings.

Wall hooks and holdfasts to be extra.

For centring, take the depth by the circumference at per square for the use of materials and time. This should be taken for each arch, although the same centring may be used many times; then it should be mentioned that the contractor may consider his price.

In joiner's work, generally describe moulded work, if possible, as ogee, quiaked, beaded, ovolo, &c., and mention girth; if this cannot be done, give a sketch and describe girth, with number of stops and miterings; describe also quality of work measured superficial and thickness, and say whether for window or door linings, grounds, window linings, carefully describing and measuring the kinds of labour in each piece of stuff.

Windows take separately, and describe as for sashes, casements, French sashes, &c.; also for shutters, describe hinges, fastenings, and ironmongery.

MEMORANDA.

50 cubic feet of timber	one load.
100 feet superficial	one square.
120 deals	one hundred.

A reduced deal is 1½ inch thick, 11 inches wide, and 12 feet long.

120 12 feet 3 inch deals, equal 5⅝ loads of timber.

400 feet superficial, of 1½ inch plank or deals, equal one load.

Planks are 11 inches wide, deals 9 inches, and battens 7 inches.

A square of flooring requires—

Laid rough - -	12¼	12 foot boards.	
Do. edges shot - -	12½	„	„
Wrought and laid folding	13	„	„
Do. straight joint -	13½	„	„
Do. ploughed and tongued	14	„	„

One square of wrought and laid folding floor requires 17 12-feet battens.

Ditto, straight joint, 18 do. do.

WEIGHT OF TIMBER.

39	cubic feet of	oak,	equal one ton.
65	„	fir	„
66	„	deal	„
60	„	elm	„
51	„	beech	„
45	„	ash	„
34	„	mahogany	„

MASON'S WORK.

There are more varieties in the method of measuring mason's work than any other trade, and nothing but a practical acquaintance with the way in which the mason takes his rough stone or marble and works it down to the shape required, will teach any person to measure his work satisfactorily.

To follow the *modus operandi:* we will suppose the stone quarried, carted, and ready for the mason, and upon his banker, each operation being taken in account as an item in the expense.

The stone should first be measured, to ascertain the amount of cubical feet it contains.

Then the labour, if merely on the face, to beds and joints, sunk, rebated, splayed, moulded on the square, moulded on the circle, plain work in the circle, in the octagon, or any other polygon; the superficial amount should be each carefully noted under its proper heading, so as to appear in the abstract, and from thence in the bill, in its proper place, in order that its own price may be put to it.

All mitering, stopping, blocks, dowells, and other matters, should be properly described as to their size and character. This will hold for all kinds of free stone; in paving it is usual to describe the superficial amount, the thickness of the stone, and the quality of the work, with all extra matters, such as sinkings, running to current, groovings, &c.

WEIGHT OF STONE.

Purbeck stone,	14 cubic feet, equal one ton.		
Portland	16	„	„
Bath	17	„	„
Yorkshire	15	„	„
Granite	13½	„	„
Marble	13	„	„
Purbeck paving	50 feet superficial		„

Do. step, 13 inch by 6½ inch, 25 feet run, one ton.

Where stone is abundant, it is usual to build the walls with it in its rough state, and to measure them by the perch of 11 superficial feet reduced, to 2 feet in thickness. To reduce all walls to this thickness, multiply the superficial

contents of all walls by their thickness in inches, and divide by 24.

In some places, however, the practice is to measure by the perch, according to the thickness of the walls. The cube perch is 36 feet.

When quoins are more highly finished than the remainder of the wall, they should be measured per foot run, and the average bed mentioned.

Describe the kind of work in facing as random coursed, quarry or squared beds and joints, hammered, picked, scabbled, &c. Every district has its own name for the particular way in which they work their walling, and their own method of doing it. This should be learnt and described.

PLASTERER'S WORK.

Measure plasterer's work by the square yard of nine feet. Where there are cornices, take the ceiling only to half the projection of cornice.

When cornices are bracketed, measure the ceilings clear of the cornice.

The sides of the room should be taken from the floor to half way up the cornice, except when they are on brick, or bracketed together, when they should be taken only to the under side of the cornice.

Number the angles in the room, and whether external or internal miters, and girth the moulding.

All enrichments take separately.

Take the coves superficial.

Friezes take as plain frieze; enrichments in frieze take separately.

MEMORANDA.

1 hundred of lime = 25 strike bushels.

100 yards of render set require	1½ hhd. of lime 1 double load of sand 4 bushels of hair	Plasterer, labourer, and boy, three days each.
130 yds. of lath plaster and set require	10,000 nails 2½ hhd. of lime 1½ double loads of sand 7 bushels of hair	Plasterer, labourer, and boy, six days each.

1 bundle of laths and 384 nails will cover 5 yards.

187 yards of render only	1½ hhd. of lime. 2 double loads of sand. 5 bushels of hair.

Floating requires more labour, but not half the quantity of stuff as rendering.

375 yards of setting only	1½ hhd. of lime. 5 bushels of hair.

20 per cent. is allowed on the primary cost of materials.

IRONMONGER.

Nails are sold by weight, and charged by the hundred. Screws at per dozen. Iron bolts and screws, at so much each. Brass flush bolts, at so much per inch. Pulleys, each, according to diameter. Hinges and screws, at per pair. Locks at so much each.

Twenty per cent. profit on prime cost of all articles.

IRONWORK.

Cast iron in girders, story posts, columns, &c., is charged by the ton or cwt.

Moulds, if purpose made, are charged extra.

Common articles, such as railings, gratings, casements, brackets, &c., are charged at per pound, according to the value of the work.

Wrought iron in chimney bars, railings, hand rails, shoes, &c., charged at per pound.

PAINTER.

In painter's work, all painting not cut in on both edges, must be taken, including edges and projections, at per square yard of nine feet.

Work cut in on both edges, as cornices, skirtings, shelves, &c., at per foot run.

Ornamental work first taken as common, and then superficial for labour to ornaments, at per foot superficial or foot run.

Sash frames, window lights, casements, bars, dormers, frontispieces, chimney pieces, &c., numbered and valued at per each. Sash squares at per dozen.

Iron or wood railings, stair ballusters, &c., are measured on both sides as solid work to allow for the extra trouble of painting round the bars, rails, &c., at per yard; add extra for any ornament, or for turned work.

Letters or figures, numbered and valued at per inch in height.

MEMORANDA.

45 yards of first coat, including knotting, stopping, and every preparation requisite for the second coat will require	5 lbs. of white lead. 5 lbs. of putty, litharge, &c. 1 quart of oil.
Second and following coats ...	5 lbs. of white lead. 1 quart of oil.

20 per cent. profit is allowed on the prime cost of all materials.

GLAZIER.

In glazier's work, measure between the rebates, and all irregular panes, the largest dimension each way.

The price must be calculated from the prime cost per crate, allowing for carriage, and 20 per cent. profit. The larger the panes the greater the difficulty and risk and waste in cutting, fitting, and setting; consequently the price should increase in proportion to the size.

		ft.	in.		ft.	in.	
Panes whose superficial contents are under	...	2	0	at			per foot.
Do.	do. from	2	0	to	2	6	add 1d.
Do.	do. „	2	6	to	3	0	add 2d.
Do.	do. „	3	0	to	3	6	add 3d.

above the squares whose contents are under 2 feet.

A crate of crown glass contains

12	tables of the best	at	per crate.
15	„	seconds	„
18	„	thirds	„
18	„	fourths	„

Each table is from 4 ft. to 4 ft. 6 in. diameter.

The average product of each table is about ten feet.

Quarry glazing is valued at per foot superficial. Measure the whole height and width of each light, including the rebate or groove, and the greatest dimension of each division in tracery. Tinted or Cathedral glass is generally used for this work.

Plate-glass is valued at per foot superficial, and the quality required must be described as polished plate, rough, Hartley's, &c.

PAPER-HANGER.

A piece of paper is twelve yards long, and when hung, twenty inches wide. Twelve yards run equal $6\frac{2}{3}$ square yards, or sixty feet superficial; therefore, divide the superficial feet by 5, will give the number of yards, and these divided by 12, will give the number of pieces of paper.

Allow one piece in seven for waste.

RULES FOR THE MEASUREMENT OF WORK.

The way in which measurements are taken may be divided into the following operations :—

1. Taking the dimensions.
2. Squaring, abstracting, and forming the bill.
3. Preparing the estimate, in which the various items of the bill are priced, then moneyed out and cast up for the result.

The work is "measured up" from the actual completed result, or taken from the drawings before the work is executed, called "taking out the quantities," the method being nearly the same in both cases.

First, write in the dimension book, or on proper ruled paper, the name of the work, the date, and, if for "measuring up," the name of the surveyor for the opposite side.

Take the work in the order most convenient, separating the several parts, and observing always to enter the length first, then the width, and, if the dimensions are cubed, the depth or thickness.

When two or three lengths are added together into one item, let the operation be noted in the margin of the paper or dimension book.

Describe the kind of material and workmanship, and the position of the work.

If the above rules are carefully followed, they will be found useful in case it be found necessary to go back to the measurements, or should a reference to them be necessary in case of dispute.

EXCAVATING.

GENERALLY.

At per cubic yard.

Take the excavation as digging and throwing out under 6 feet in depth, and wheeling under 20 yards, or basketing, if wheeling is impracticable.

When the distance to be removed is more than 20 yards, or the depth exceeds 2 yards, or if the run-out is inclined, state particulars, also the nature of the soil must be described.

FOUNDATIONS.

At per cubic yard.

Trenches for foundations are kept separate from the general work, and described as digging trenches for the foundations, including part filling in and ramming in after the foundation walls are built and the surplus soil removed, or the digging and ramming is taken by itself, and filling and ramming form a separate item.

Where there are concrete foundations, allow the net width only of the concrete for trenches; but if there is no concrete, allow 6 inches on each side of footing, to give the waller room to work.

DRAINS, PIPES, ETC.

At per yard run.

Give depth and size of drain or pipe.

ALLOWANCES.

Except in chalk or rock, no trench is supposed to have vertical sides; therefore, an addition for sloping sides should be taken to the digging, at the rate of 3 inches on each side for every foot in depth.

For pipe drains, take the bottom of the trench about 9 inches wider than the diameter of the pipe.

SHORES AND STRUTTING.

At per yard run.

When the trench is deep and the soil loose, the length and depth should be measured for shoring and planking to the sides of trenches, instead of allowing for slopes. Under 6 feet wide, trenches should be described as strutting and planking, according to the depth and width.

WELLS AND CIRCULAR TANKS AND CESSPOOLS.

At per yard cube.

Measure as before and state depth, nature of soil, and the distance soil is to be removed.

STEINING.

Steining is usually described as "digging and steining," gear tackle, buckets, and stages, being included: state the depth and diameter in the clear, the nature of the work, and state if puddling is required, and take curbs, work in cement, and permanent pumps extra.

PUMPING.

State if, in any of the before-mentioned work, pumping will be required.

PUDDLING OVER VAULTS AND ARCHES.

At per yard superficial.

State the height of the arches above the ground level, and the thickness of the puddling required.

PILE DRIVING.

Number the piles, state the kind of timber, the scantling, and the length required to drive them.

Number the rings, points, and shoes, and state the weight of rings and shoes.

CONCRETE.

Concrete in foundations, or wherever it is 12 inches thick, is measured at per cubic yard.

Concrete under paved floors or hearths, or where it is less than 12 inches thick, is taken at per yard superficial.

In positions where concrete is lifted to a height above the ground, as in filling in above arches, it must be described, and the height stated.

BRICKLAYER'S WORK.

GENERALLY.

At per rod reduced.

Brickwork is measured superficially, in feet and inches, and the number of bricks in thickness stated.

Where the thicknesses are irregular, and in very thick walls, take all the dimensions in feet and inches, and afterwards reduce them to the standard of 1½ inch thick. Walls less than 1½ brick thick, or where both sides are faced, should be kept separate.

Circular brickwork is classified according to the curve, and is described as "flat sweep" when above, and "quick sweep" when below 25 feet radius, the face only being taken as extra; where the curve is very quick describe the work as being circular in addition to the face, as it causes more labour inside the wall.

Deductions to be calculated in the clear of openings. Window sills, stone bands or strings, or woodwork under 6 inches are not to be deducted.

Plates, or other timber on top of walls to be measured if they are not more than 3 inches in height, and if more, include 3 inches for the height for bedding and fixing.

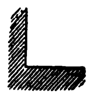
The labour on small and difficult works should be chargea separately, and no allowance in quantity made for them.

Cuttings over 6 inches wide to be measured by the foot

superficial, describe if fair cut and rubbed, and if to splays or rakes.

Facings, where ordered to be taken in addition to the brickwork, at per foot superficial, and describe as extra to face of selected bricks, including pointing, or as the case may be.

Reveals to openings to be kept separate if plastered, or if different from the face.

Internal angles  or birdsmouth, and external angles  or quoins, where the faces are not right angles, called squint quoins, are measured at per foot run, and described if to be fair or rough.

FLUES AND CHIMNEY SHAFTS.

Flues and chimneys are measured as solid, deducting only for the openings of fire-places.

Number the coring of the flues, and take fire bricks and fire lumps extra.

Chimney bars will be afterwards inserted in the smith's bill, but are to be taken here also, giving the size and the length, as 18 inches longer than the openings.

OVENS AND COPPERS.

At per foot cube.

Ovens and coppers are measured solid, deducting the ash holes, and taking the fire bricks and fire lumps extra.

ARCHES, VAULTS, AND GROINS.

At per rod reduced.

Take the mean girth by the length and thickness, and describe them, whether straight, askew, spandril, curved, or otherwise.

In groined arches, when the groins spring from four piers or angles, the parts groined are kept separate, and the run of cut and rubbed groin point taken in addition. In other cases, take the cut and rubbed groin point only. In all cases, the thickness of groined arches should be stated, in order that the amount of rough cutting at the intersection of the arches may be known.

Measure the soffits of all arches and vaults for centring, that for groined, curved, and circular spandrils to be kept separate. Take groin points, cuttings, and extra ribs where required.

Take raking out and pointing to soffits, which cannot be performed until the centres are struck.

Take rough cuttings for skew-backs, and cuttings where arches are not straight; the faces of skew arches require to be face cut.

Take rough cutting to walls, cut to fit the wall ribs. Trimmer arches are to be taken at per foot superficial stating the thickness.

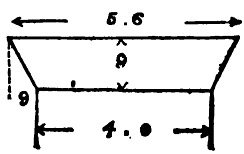
GAUGED ARCHES.

At per foot superficial.

Gauged arches over openings to be taken as extra to the brickwork, deducting for facing only.

Measure the width of the opening between the reveals, and add the projection of one skew-back. This length by the height will give the face, to which add the soffit; thus,

ft. in.
4 9 extra to gauged arches,
9 and deduct external facing.
—
4 0 add gauged
4½ soffit.



ft.	in.	
4	0	opening
	9	skew-back
4	9	

With curved or cambered arches the method is the same, the net soffit and face being taken.

Take centres for the curved arches at per foot superficial.

Take turning pieces for the straight or cambered arches at per foot run, stating depth of soffit.

POINTING AND RENDERING.

At per yard superficial.

Describe pointing as raking out joints, and pointing with fine mortar as tuck pointing, or flat pointing, as specified or executed, or as "pointed as the work proceeds."

Describe rendering in cement, and charge as rendering from the trowel.

BRICK NOGGING.

At per yard superficial.

Take the superficial dimensions, and deduct openings, but not timber.

TILE OR BRICK PAVING.

At per yard superficial.

Describe the tiles or bricks used as to quality, size, and thickness, if the bricks are laid flat or on edge, in mortar or sand, and the tiles if laid and rendered in mortar or cement.

BRICK COPINGS.

At per foot superficial.

Describe whether moulded with roll, or saddle-back, or brick on edge, and state if set in cement or mortar, and take iron knees at openings and stopped ends.

DRAINS.

Per foot run.

Describe if set in mortar or cement.

Barrel drains must be described by the number of half-bricks in thickness; centres, moulds, and templates to be charged extra. Bends and junctions are charged extra in pipe drains.

Digging should be taken in the excavator's work.

CESSPOOLS.

Describe whether square or circular, also the depth and width in diameter, the lining, and whether rendered on the inside with cement.

Take for making connections with cesspools for all drains.

GENERAL ITEMS.

Number the ventilators and air bricks built into the walls, and forming and rendering the apertures for them. Take for chimney-pots and fixing, and for ranges, stoves, and chimney-pieces fixing. Number the mitres and stopped ends to all splays, rounded angles, &c., and take the bedding and pointing to door and window frames, and ends of timbers built in and cut and framed.

"Labour only" is exclusive of scaffolding, but includes its erection.

"Labour and mortar" includes scaffolding and other materials, except bricks.

TILER.

ROOF TILING.

Superficial square of 100 feet.

For plain tiling, take the whole superficial area, and allow extra for the eaves next parapets 4 inches; dripping

eaves 6 inches; all hips and cuttings 3 inches; and for valleys 12 inches.

For pantiling, also take the whole superficial area, and at hips, take the length of the hip rafter by 12 inches for cutting and waste, to be added to the superficial area; take the run of hips and ridges, and of mortar or cement filleting, and the plain tile heading.

Take in all cases the number of hip hooks and T nails, to be painted in oil.

State the gauge of the tiles, the quantity and description of the laths and nails used; also if laid dry, or pointed outside or inside with mortar, or if laid in hay.

STONE WALLING.

Stone walling is usually built of rubble stone, and measured by the cubic yard, unless there is some local standard in general use, and is classed as "coursed," "random coursed," "uncoursed," "in foundations," and "filling-in between or behind dressed stone faces."

Measure the face work separately, and price at per superficial foot, and describe the workmanship as "scabbled," "hammered," "axed," "quarry-faced," and include any squaring to the beds and joints.

Quoins, if of larger stones or longer on the bed than the other part of the walling, to be taken at per foot in height; and where they are dressed to a finer face, the labour is to be taken separately.

FREE STONE WORK.

In the quarry stone is charged at per cubic foot or per ton, and the price varies as follows:—

1. When one dimension is fixed, as in the height of a

course of ashlar, and the other two dimensions (the length and bed) are left somewhat to the quarry-man.

2. When the height and length, as for a string, are fixed, and the bed is left optional, or varied between two dimensions.

3. If all the sizes of the blocks are fixed.

The price of a block of stone varies according to the amount of work; as if the back is left rough to tail into the walling, or if the joints, or portions of them, are left rough.

Ashlar, or walls of block stone, are measured at per cubic foot, and described as ashlar prepared and set, including all beds and joints, and the face is measured extra and charged as "drafted and picked," "tooled," "rubbed," &c.

Stone dressings, as strings, cornices, arch stones &c., are charged at per foot cube for the stone and setting, the dimensions being taken as from the smallest block it could be prepared; and the labour on the face is measured on the finished block, not on the surface, and described as beds and joints, sunk joints, plain face, sunk face, moulded, circular moulded, &c.: or a quicker method is to make an addition to the price of the cubic foot of stone for plain beds and joints, and then only the labour on the face and sunk joints are taken as superficial work.

In London, where Portland or Bath stone is most generally used, it being easily sawn into scantlings, the work is measured thus:—

MATERIAL.

Per foot cube.

Take the size of the stone as it comes from the banker, and describe "cube stone, including hoisting and setting."

All stones more than 6 feet long to be described as scantling lengths, and each size to be kept separate.

Where the work is more than 40 feet from the level of the ground, the height is to be stated.

All stones under 3 inches in thickness to be measured by the foot superficial.

LABOUR.

Per foot superficial.

Measure each bed and joint, and describe the work in cornices, strings, and other horizontal work; one joint to be allowed every 3 feet in length only.

Half sawing to be taken to all sawn faces on which no other labour is to be taken, (including the original faces lost in sunk work).

Plain work rubbed (which includes sawing), to all faces and returned ends, unless otherwise worked.

Sunk work, moulded work, circular plain and circular moulded work to be measured by the girth; and take half sawing to the original faces extra.

Mitres to sinkings, sunk rebates, grooving, throating, back joints, splayed and fair edges under 6 inches wide, chamfers, reeds, flutings, haunches, joggle, and iron or copper-tongued joints, cutting and framings to landings, are to be taken by the foot run.

Number fair ends to steps, holes, cramps, plugs, dowels, mortise holes for door posts, rounded corners, notchings, letting in gratings or plates, traps, sink stones, pinning and cutting to ends of steps, stopped and bevelled ends to sinkings, internal and external mitres to mouldings (stating the girth), returned and mitred ends to copings, neckings to chimney pieces, &c.

DESCRIPTION OF TERMS USED IN LABOUR ON STONE.

Plain Work, is the wrought face produced by merely removing the irregularities of the stone, without sinkings.

SUNK WORK, is the cutting below the plain face, as in rebating or weathering.

CIRCULAR WORK, is the labour on convex or concave surfaces, as to the shafts of the columns, arch stones, or walls circular on plan.

CIRCULAR CIRCULAR WORK, is when the plan and section are both circular, as in a sphere.

MOULDED WORK STRAIGHT, is to cornices, strings, &c.

MOULDED WORK CIRCULAR, is to capitals, or bases of columns, &c.

EXAMPLES OF THE METHOD OF MEASURING FREE STONE WORK FOR MATERIALS AND LABOUR.

PLAIN SOLID STEPS.

Per foot run.

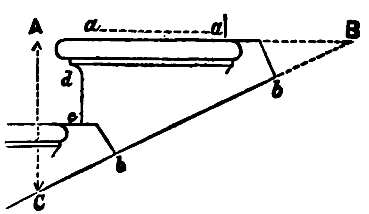
Measure length and describe width and height, state if tooled on tread and riser and backjointed, or tooled all round.

Take wrought or rounded ends, or cutting and pinning to walls, &c. extra.

When bedded on brick or stonework it should be described.

SPANDRIL STEPS.

For cube measure of stone, take the nose of head at A to the apex of triangle at B for the width, and half the height from top of head at A to C in a



vertical line from nosing to the soffit, for the depth: this, with the length of step, will give the cube quantity.

Take tread and soffit, *a a* and *b b*, as plain work rubbed. Take girth of rebate (*b c*) by the length as sunk work. Take length of nosing (including returned end) by the girth as moulded work, and face of riser (*c d*) as sunk work.

Take sawing to the original surfaces of the sunk and moulded work.

The under side of spandril winders to be taken as circular plain work.

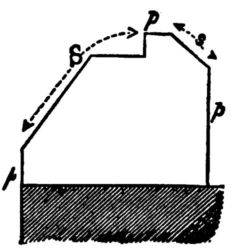
Number mitres to moulding, and state girth.

 „ returned ends to moulding.

 „ steps cut and pinned into wall.

 „ holes cut for balusters.

WINDOW SILLS.



Take the extreme length, breadth, and height for cubic quantity of stone.

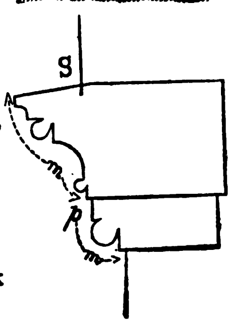
Plain work, *p*, for the top, front, and back.

Sunk work, *s*, *s*.

Width and length of bed.

Sawn sides and ends as half sawing, if no other labour is taken.

CORNICES.



Take cube quantity of stone as before described.

Beds and joints for the top, bottom, and ends.

Plain work at *p*.

Sunk work at *s* (girth).

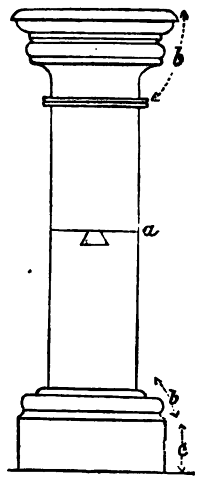
Moulded work *m*, *m*.

Half sawing to the face and back (if sawn).

Run of groove for plug.

Number of plugs and running with lead.

COLUMNS.



Shaft, exclusive of base and capital.

For the cube quantity take the extreme size of the stone as if square.

Half sawing on two sides (if sawn).

Plain joints (*a*).

Half plain work on two sides.

Circular plain work to girth of shaft.

Number of mortise holes and dowels.

Capital and base.

Take extreme dimensions for material as before.

Half sawing (as before).

Half plain work (as before).

Circular moulded work *b b* (girth).

Circular plain work (*c*) (girth).

For ordinary scantlings, Yorkshire stone for curbs, steps, &c., may be obtained ready dressed from the quarry, and they are usually taken at per foot run, and charged at lower rates than if they were prepared in London from the block stone.

Yorkshire pavings and landings are measured by the foot superficial, and described if tooled or rubbed on one or both faces, or otherwise.

When the tooled edges to landings are over 6 inches wide, take by the foot superficial, and when under 6 inches, by the foot run, describing width. Take joggle joints, cuttings and pinnings, &c., to landings, the same as for other stone steps, as before described. When a close-fitting joint is required, take coped edge to paving.

In granite, all stones are measured at their largest dimensions for the cube contents, as it cannot be sawn. All beds and joints to be described as "plain picked," or "plain axed beds and joints."

When the stone cannot be sawn, as in granite, two beds and two joints are usually taken, where only one would be taken to Bath or other sawn stones.

SLATER.

Slating to roofs is measured by the square of 100 feet superficial. Give the size and usual description of the slates, their gauge, and the description and weight of nails to be used.

If the slating is circular or upright, it must be measured separately, and an additional price put down for the extra labour.

Take the extreme length of the eaves by the width from the eaves to the ridge, and make no deductions for hips, without they are very extensive.

All openings, such as chimneys or dormers, to be deducted, but allow the run of edge round the same by six inches for cutting and waste.

For all raking edges and irregular angles, add the length by six inches, also for all hips and valleys. If an extra length of slate is used at the eave, allow the length by the gauge of the bottom course.

Take run of filleting, and describe if in mortar or cement, flush or bevelled.

SLATE MASON.

Measured by the foot superficial.

Slate shelves.—Take length by extreme width, state

thickness, if rubbed or planed on one or both sides, and state the actual size, if over 6 feet in length or 3 feet in width.

Take sawn, rubbed, filed, bevelled, or rounded edges. fillets rebated or grooved, and tongued joints, stating if in red lead or putty, all at per foot run. Take cutting and pinning to walls at per foot run.

Number holes (according to diameter), notches, and rounded corners, stating the thickness of the slate, also the kind of screws used and the holes for the same.

Slate cisterns are usually numbered and described according to the capacity and manner of putting together. Holes for pipes and fixing are taken extra.

Slate skirtings and covers to hips and ridges are taken at per foot run, according to thickness and width. State if bedded in putty or red lead. Number screws and drilling holes for the same.

CARPENTER.

The work usually described under this heading is that where timber is used in large scantlings, such as roofs, floors, partitions, &c. It is usually measured by the foot cube, and the full quantity of timber used, such as tenons, bevelled ends, scarfs, &c., are included in the measurement. Deductions are sometimes made when the part cut out is available for other work, but in those cases a liberal allowance must be made for waste.

The labour on timber is classified as "fixed only," "framed," or "framed and fixed."

Timber fixed includes the labour in nailing, spiking, halving, dovetailing, or notching.

Timber framed includes mortising and tenoning.

BOND TIMBER AND PLATES.

Take bond timbers, wall plates, pole plates, templates, and lintels under this head at per foot cube, and add for laps, dovetails, and scarfings, in the measurement.

Deduct half the length of bond timbers to door or window opening.

NAKED FLOORING.

Take all joists and sleepers which have not been actually framed at per foot cube as "fixed" only.

Ground joists and sleepers to be taken distinctly from upper floor joists.

Trimming joists, trimmers, binders, and girders are to be taken as framed.

Girders sawn down the middle, reversed, and bolted, or trussed, are to be kept separate.

Take oak trusses at per foot run. State the scantling, and if in unusual lengths. Letting in screw bolts, plates, &c., are to be numbered as extras.

Take strutting between the joists by the foot run. State the scantling, and if herring-bone or otherwise.

WOOD BRICKS.

Number the wood bricks, state the size, and if cut on the splay.

ROOFS.

Common rafters, purlins, diagonal ties, wind braces, dragon pieces, and gutter plates to be taken at per foot cube as "fixed in rafters."

Each piece of the principal trusses to be taken separately at per foot cube, and described as "framed in trusses."

One shoulder to be taken from king posts, and one-half from queen posts.

Allow for length of tenon in all cases.

Add extra for fixing to all iron work.

Ridges, hips, and valley pieces to be taken by the foot superficial. Allow for laps, and measure cuttings and waste by the foot run.

Slate boarding or battening, boarding on top of rafters, and felt to be taken by the square of 100 feet superficial.

Cuttings and bevelled edges, tilting fillets to slate boarding, feather-edged eaves boarding to slate battening (state width and thickness), hip and ridge rolls (allow for laps, and state diameter, if spiked or otherwise), all to be taken by the foot run.

Gutters to be taken at the average width, and when the roofs are battened, include half the lear boards. State the thickness of gutter boards, the size of bearers, distance apart, and if framed.

Drips and cesspools to be numbered. A fillet is used to tilt the slates, instead of lear boards, when roofs are slate boarded; these should be taken by the foot run, as to eaves, boarding, &c.

For trap-doors, deduct the rafters for the opening, add trimmers, and take trimming rafters, &c., as framed, or allow for extra labour in trimming the rafters.

Take linings to the opening and the run by the foot run. State the width and thickness of each, and if wrought splayed or dovetailed at the angles.

Measure the trap-door by the foot superficial. State thickness, and describe as wrought, ledged, and filleted, as the case may be.

Take to each trap-door a handle and bolts, according to description.

QUARTER PARTITIONS.

Heads, sills, braces, quarters, door-heads, and other openings, take at per foot cube, and describe as "framed and trussed partitions," or as the case may be.

Deduct doorways and other openings.

The quarters, when tenoned into sill and head and spiked to the braces, are to be considered as framed.

Hogging-pieces take at per foot run. State width and thickness.

Iron work and fixing take extra.

CEILING JOISTS.

Ceiling joists, take the same as floor joists, by the foot cube, and take the trimming as described for roof.

WALL BATTENING.

Wall battening take at per square of 100 feet superficial; take the length round the walls by the height. State thickness, width, and distance apart; also, if plugged to the wall or otherwise; and deduct all openings.

ROUGH BOARDING.

Rough boarding take at per square of 100 feet superficial. When the shape is irregular, take the average for the length and width, allowing extra for all cutting and waste at per foot run. State thickness of boarding, and describe edges as "shot, ploughed, and tongued," or otherwise.

Boarding to ceilings or walls should be kept separate, as requiring more labour. If laid to a fall, take firrings by the foot superficial, stating average size and distance apart.

SOUND BOARDING.

Take sound boarding at per square of 100 feet superficial. Measure length by width, including joists, and state if on

angle or double fillets. Sometimes the width only between the joists is taken, in which case it must be mentioned, as it will regulate the price.

BRACKETING.

Measure bracketing by the foot superficial. When for cornices, take the length round the room, deducting one projection of the cornice each way by the girth. State the thickness of deal, &c., plugged to wall. Take angular brackets extra, and number them.

Bracketing to circular and groined ceilings to be taken similarly. State if the diameters are small.

If done in small quantities, state in all cases.

SOLID DOOR FRAMES.

Per foot cube.

Take the round of the frame, including the tenons into the head. Add 6 inches for the horns, and 2 inches for each stub to the sill.

Take the oak sill separately, the length by the width or thickness.

State if wrought, framed, rebated, and beaded, double-beaded, or otherwise. State if the oak sill is wrought, framed, and weathered.

If the sill be stone, take iron shoes and fixing to the feet of the door frame.

WROUGHT, FRAMED, AND ROUGH TIMBERS GENERALLY.

Wrought timbers under three inches square are taken at per foot run, according to scantling.

Large timbers partially wrought are usually taken as if rough, and the labour of planing taken extra at per foot superficial, and the rebating, beading, moulding, &c., by the foot run, the girth of mouldings being given.

Circular timbers are measured as they appear, adding the laps, scarfs, &c., the labour and waste being charged in the price.

State if a flat or quick sweep, a rise of less than half an inch in a chord of a foot being a flat sweep.

If the curve is elliptical, or made up of a combination of circles, it should be stated.

State when timbers of more than 20 feet cube are hoisted over 30 feet. Unusual lengths should also be mentioned.

CENTRING.

(See Bricklayer.)

Centring to vaults is charged at per square of 100 feet superficial. Centring to trimmer arches, gauged, and other arches over openings, when the soffit is more than 9 inches wide, are taken at per foot superficial; if under 9 inches in width, by the foot run. Describe the nature of the curve.

Feather-edged turning pieces to trimmers take at per foot run.

FENCING.

Wood fencing is generally measured by the lineal rod of 16½ feet, and charged according to description; but fancy fencing must be taken in detail.

JOINER.

As the work done by the joiner is spread in a much greater proportion over the surface, it being chiefly in the wood fittings to buildings, and as such is worked in much thinner stuff than the carpenter's work; it is, therefore, instead of being measured by the cubic foot, taken in superficial dimensions of feet and inches.

The terms "fixed" and "framed" may be defined as in

carpenter's work, with the exception that, in the joiner, the length of the tenons is omitted.

FLOORING.

Per span of 100 *feet superficial.*

Take the length by the width, and add any filling in pieces to recesses, doors, or windows.

If the walls be not at right angles, take the average size.

Cuttings to raking sides to be allowed for.

Slabs, chimney breasts, or other projections, to be deducted for.

State the kind of material, mode of laying, and thickness of stuff.

Glued and mitred borders to slabs to be taken extra.

SKIRTINGS.

Per foot run.

Take length round room, and add for passings at angles. State thickness and width, and whether moulded or otherwise, and if tacking fillets are included.

Tongued or mitred angles and housings to be taken and numbered.

NARROW GROUNDS.

Per foot run.

Measure as skirtings, and describe if chamfered, plugged to wall, or otherwise.

SASHES AND FRAMES.

Per foot superficial.

Take the width between the pulley stiles, adding 4 inches on each side for the frame; for the width take from top of sill to under side of head, and add 4 inches for the head and 3 inches for the sill.

Describe the sill, as single or double sunk, weathered or throated, and if of oak, the thickness of the pulley stiles, heads, and linings, the size of the sash beads, thickness of sashes and sash bars, and if moulded or otherwise, the mode of hanging the sashes, the quality of the lines, pulleys, and weights.

Number sash fasteners, and describe them.

SASHES AND FRAMES, CIRCULAR ON PLAN, OR WITH CIRCULAR HEADS.

Per foot superficial.

Take the height by the girth, adding for frame and sill as for straight sashes and frames.

State if quick or flat sweep, and describe similar to straight sashes and frames. Describe fasteners and number them.

With circular headed sashes and frames take the lower part to the springing of the curve, the same as for square headed, then take the circular head separately, the height by the width, and describe as "circular heads to sashes and frames measured square."

SASHES AND SKYLIGHTS (FIXED).

Per foot superficial.

Take the width by the height from outside to outside, and if two sashes in height allow 1 inch for the meeting rail; state the thickness, and if the bars are square, chamfered, or moulded.

Beads, stops, and linings take by the foot run; and describe thickness and width, and the labour upon them.

INSIDE WINDOW FITTINGS.

Per foot superficial.

Window Linings and Window Boards.—Take the width by the length in each case, and allow for passings at all

mitred angles. State the thickness, and if grooved or rounded. State if window boards are tongued to the sill, and rounded on the edge.

Architraves and Framed Grounds.—Measure the length on the outside edge by the width. State the thickness, and if grounds are beaded, mitred, or back rebated; if moulded, and under 4 inches girth, take at per foot run, if over 4 inches, at per foot superficial. Mouldings on architraves are all charged at per foot superficial.

Shutters and Back Flaps.—Take the height by the width of shutters, including the rebates.

Take the back flaps in a similar manner, but keep them distinct.

Describe thickness of shutters, the number of panels, and if hung in one or two heights, also if square framed, flush panel, moulded or otherwise. The back flaps to be described in a similar manner, and kept distinct.

Hinges according to size and material, if of cast iron or brass, according to pattern; describe price, if specified, if not, give sketch.

Shutter bars according to length and description. Holes cut for ditto.

Shutter knobs and escutcheons according to description.

For back linings add 2 inches to the height taken for shutters by the width; state thickness, and if square, flush moulded, splayed, or stopped.

For boxings take the height, including the framings, by the width.

Sliding Shutters.—Take the height by the width, and state the number of panels, the mode of framing, and the number of heights. Give the size of pulley pieces and beads, the quality of line, the weights and pulleys.

Take run of groove for beads.

Take run of flap, according to thickness and description, hinges to flap, and flush rings to shutters.

Take boxings, grounds, &c., as for window fronts below.

Window Backs, Elbows, and Soffits.—Take the length of back and elbows, including passings at angles, by the height from floor to under side of capping.

Soffit take by extreme length and width.

State thickness and number of panels, also if keyed square, splayed plain, flush panel, moulded, or moulded or chamfered, and stopped.

Take beaded capping to window back at per foot run, number the elbow caps, and bead according to size and description.

OUTSIDE SHUTTERS.

Per foot superficial.

Take the height by the width, and, if folding, include the rebates.

State the thickness, the number of panels to each fold, the mode of framing, and give a description of the mouldings. Hinges, rings, and turn buckles at per foot run, and hanging style at per foot run, stating width and thickness.

Number perforations in panels (if any).

DOORS AND FITTINGS.

Per foot superficial.

Ledged and Ledged and Braced Doors.—Take height by width, including rebates, if hung folding.

State thickness of door, and size of ledges, and whether chamfered or stopped, and if "proper ledged doors," that is to say, whether wrought, ploughed, tongued, and beaded. State also if they are braced.

Hinges, locks, latches, and bolts as described.

Framed or Panelled Doors.—Take the height by the width, and if folding, include the rebates.

State the thickness of the doors, and the number of panels, described as given for shutters,

Circular heads to be taken separately, and measured square from the springing.

Hinges, locks, bolts, knobs, &c., if to pattern, in all cases give sketch.

Jamb Linings.—Collect the length by adding twice the height of sides to the width of doorway, adding four times the thickness of linings.

Give the thickness, if tongued to frames, if single or double rebated, if beaded on both edges, and if framed in panels, stating the number and description.

Give the number of blockings (dovetailed or otherwise) to receive hinges and lock.

Framed Door Grounds.—Take the length by the width; to do this take that of the door jambs, and add for the passings at the angles four times the width of ground.

State thickness, and describe according to the amount of labour.

Take the mouldings round the grounds, or the architrave, as described for windows.

FRAMED GATES.

Per foot superficial.

Take the height by the width, including the rebates, if hung folding.

Give the thickness of gate, and how framed and hung.

Take the run of capping according to description.

Take hinges, bolts, latches, swing bar, or other fastenings and iron lining to sill, stay hooks and eyes, and fixing.

If there is a wicket, then extra for forming, fitting, and hanging.

STAIRCASES.

Flyers.—Take the extreme length of the treads, including the housings into the strings by the collected widths of the treads, measured from the front of the riser to the nose of the tread, for the risers take the same length as tread by the height, and keep separate, if they are not of the same thickness as heads, as is often the case.

Give the thickness of the treads and risers with the number and size of the carriages.

If the steps are wrought, glued, or blocked, or if with moulded or rounded nosing, or if cut and united to string, or housed to string at one or both ends, must be stated.

Take housings to the steps and risers, dovetailed sinkings for balusters, grooving and tonguing, and run of nosing on the floor to form the upper steps. Number cut brackets or returned moulded nosings (if any).

Curtail end to bottom step according to description. Fascias and apron linings take per foot superficial according to description.

Winders.—The superficial extent of the heads and risers to be taken, adding the projection of nosings for each tread. State thickness, &c., as for flyers. Grooving and tonguing to be taken by the foot run. The housings to be numbered and kept distinct from the flyers, run of returned nosings to steps, and the number of cut brackets.

String Boards.—Take extreme length, including framings, &c., by the width.

Give thickness, and state if sunk or double sunk, moulded, cut and mitred to risers, framed, rebated, beaded (and stopped), if solid wreathed or wreathed in thicknesses, or cylindrical mould with proper backings.

Number the housings, splayed ends, ramps, and tongued angles.

If the circular parts are under 6 inches, radius must be stated.

Per foot run.

Newells.—Measure the height and include tenons, state the size and shape, and if single or double, or turned.

Number the cut tops and feet (if any), and give sketch.

Iron screw-bolt and fixing.

Handrails.—For the length, measure along the middle of rail, and keep separate the parts that are straight, ramped, wreathed, and circular.

Give the size, and if moulded give sketch; circular or wreathed parts to well holes of less than 12 inches opening, must be stated.

Iron cores (if any), number of handrail screws and fixing number of scroll ends, screw nut and joint to cap, &c.

Ballusters.—Give the height, including the tenons, if framed; state the size and shape, and if moulded, nailed on both ends, or if dovetailed.

The scroll filling in of Elizabethan staircases must be taken superficial, the thickness given, and described by sketch or otherwise.

If iron ballusters are used, they must be taken, and the number of screws and fixing.

WATER-CLOSET FIXINGS.

Per foot superficial.

For the seat and riser take the extreme length and width of seat, and add the height of riser.

For flap and frame take the length and width.

Give the thickness of seat and riser, state if made to shift, and describe flap and frame.

Rounded or moulded nosing round the seat or under flap take at per foot run.

Take the holes for the handle and for the pan, and describe.

Number hinges and describe.

PLASTERER.

Per yard superficial.

Rendering to walls.—Take the length and height of the walls from the skirting grounds to the ceiling, deducting openings; and if there is a plastered cornice deduct half the depth, unless the cornice is bracketed, in which case deduct the whole depth.

Give the number of coats, state if in mortar or cement, and if floated and set, or set, as may be.

Take run angle beads or quoins extra, and state if in cement.

Ceilings (lath and plaster).—Take the length and width between walls; if there is a bracketed cornice deduct the projection, unbracketed, deduct half the projection.

Describe laths, whether single, lath and a half, or double laths.

Give the number of coats, if floated, set, or both, and if with putty.

Friezes and other enrichments take by the foot superficial. Pateras to be numbered, and all to have full descriptions. Raised panels take extra by the foot superficial. Take the mouldings by the foot run, and give the girth and number of mitres.

Partitions (lath and plaster).—Measure as described for rendering, and describe.

Cornices.—Measure length by the walls, and deduct one projection each way. Should the projection be more than

6 inches, take it by the foot superficial; if under 5, the girth, and take by foot run.

Enrichments by foot run. State if undercut, and give girth.

Coves take by the foot superficial.

Number all stopped ends, mitred angles above fan, &c. State girth, and whether mitres are external or internal.

Stucco.—State if on bricks or laths, bastard or trowelled, and take per yard superficial.

Arrises, beads, quirks, narrow widths, and reveals take by foot run.

Skirtings.—Take by foot run. State width, and how finished, and if flush. Number the angles, and if internal or external.

Limewhiting, Colouring, &c.—Take per yard superficial, and describe. Cornices to be taken run, and girth given.

Note.—Circular work in all plastering must be kept separate, and described.

SMITH AND FOUNDER.

Both cast and wrought iron are usually sold by weight, except in very elaborate workmanship. The dimensions must therefore be taken in feet and inches, and afterwards reduced. Each article must be kept separate and described, and where to pattern, a sketch should be given in all cases.

Wrought Iron.—Take by the foot superficial, and reduce weight in the abstract.

Number holes for bolts, rivets, &c., and give thickness of iron. Number small bolts and rivets.

Cast Iron.—State pattern, and take filing, chipping, and fitting by the foot run.

PLUMBER.

Lead should be taken, with great care, in superficial dimensions, keeping the several weights distinct.

Lead roofs, gutters, flats, and flashings, are taken by the cwt., including the lead and labour, and kept distinct.

Cesspools, sinks, cisterns, &c., taken similar to gutters, &c., and kept separate.

Soldering to joints, angles, &c., and nailing extra at per foot run.

Pipes, take per foot run, give diameter and weight, joints extra. Number cocks and fixing, give size and description, and state if with spanners or keys.

Washers, wastes, plugs, air-traps, gratings, screw or driving ferrules, and fixing, give size and description.

Water-closet apparatus, describe accurately, the mode of fixing, traps, &c.

Pumps and fixing according to price.

Suction and supply pipes and making good to pumps, also fixing and wall-hooks extra.

Making good to soil and other pipes take extra.

PAINTER, GLAZIER, AND PAPERHANGER.

Painter.—The rule is to take all surfaces painted by the superficial yard, except where it is necessary to work to a line, as in skirtings, where, it being necessary to protect the floor, it is called "cut in both edges."

State if knotted, stopped, flatted, or otherwise, the number of oils, and if in common or ornamental colours. If in ornamental, give the names.

Common colours are produced by mixing white lead and

oils with English or Turkey umber, Spanish brown, lamp-black, red lead, Venetian red, or any of the common ochres. Ornamental colours are Prussian blue, indigo, mineral green, the rich reds, pinks, and yellows, &c.

Rain-water pipes, edges of copings, and to shelves, stone strings, cornices, hand-rails, skirtings, take by the foot run.

Work done from a ladder, such as cornices, should be kept separate.

Number sash frames (outside only—the inside are taken with the linings), sash squares (each side), per dozen.

Ornamental work, such as capitals, should be numbered and described, as such work cannot be measured.

Letters, according to height, and describe as plain or ornamental.

Describe singly newells, ballusters, door-scrapers, brackets, door-fastenings, chimney-pieces, window sills.

Glazier.—Take the full dimensions of panes, when they are square; and if circular or irregular, take the extreme size, as if they were square. Large squares take separate. State quantity, and if stopped into old or new sashes. Cleaning, including breakage, is usually charged at per dozen panes, each side being numbered, and large panes being kept distinct.

Paperhanger.—Paperhangings are charged by the piece of 12 yards long and 20 inches wide.

Find the superficial extent of walls in feet, divide by 5, for yards run of paper, and by twelve to bring it to pieces, or divide by 60 will obtain the result.

Charge odd yards as one piece.

Charge extra at per piece pumicing and preparing walls, lining paper, and hanging.

Borders take at per dozen yards run.

GASFITTER.

Gas pipes, including fitting and fixing, take by the foot run, according to size. Describe quality.

Number crosses, elbows, sockets, T pieces, reducing sockets, outlets, and extra.

Take meter, governors, siphon traps, pendants, and other fittings, and describe.

Opening the ground and filling in take at per foot run, stating depth.

Number holes through walls and making good, and state thickness of wall.

ABSTRACTS AND BILLS OF QUANTITIES.

FORMING THE ABSTRACT.

The dimensions are to be carefully calculated and checked, always by another person than the original calculator; or, if a junior is employed in the work at all, let him first square or cube the dimensions, and let a responsible person afterwards check his working.

When this is done, then the dimensions should be carefully gone over, and, in order to make the abstract columns as small as possible, it is usual to add together in the quantity book all dimensions that are in column, of the same kind or description of labour and material.

The abstract sheets should then be commenced, upon properly ruled paper, and remember that on the clear arrangement of this work depends, in a great measure, the correctness of your estimate; because, when the work is checked, should it be clearly arranged, the work of checking or ticking off the items as they are found in the dimension sheets will be so much lighter, that there is much less chance of a blunder arising; on the other hand, a confused abstract sheet is difficult to check, and, if any difficulty arises, the trouble in judging the different items makes it more probable that something may escape either in checking or in the next operation, that of "billing," as it is called, or forming the bills of quantities.

The different trades should be taken in their order, thus:—

1. Excavator.
2. Bricklayer.
3. Mason.
4. Carpenter.
5. Joiner and ironmonger.
6. Slater (or tiler).
7. Smith and plumber.
8. Plasterer.
9. Glazier.
10. Painter.
11. Gasfitter.

In each trade, begin on the left hand of the abstract sheet with the cubic quantities, and with those of the least values; secondly, proceed with the superficial quantities; thirdly, with the runs; and, fourthly, with the numbered articles.

Keep in separate columns those quantities in which labour only, and material and labour, are taken.

Lastly, put in a separate column those articles for which a sum is allowed.

BILLS.

The abstract being carefully filled in, and as carefully checked from the bills of quantities, the dimensions in column cast up, and, as in the case of brickwork, reduced to a common value, or in lead or other metal-work, then proceed with the bill of quantities.

Each trade should have its separate heading, thus:—

ESTIMATE

for the erection of____________________________

for ____________________________________

____

Architect.

__________ 18 _____

EXCAVATION, BRICKLAYER, AND DRAINS.

CONCRETE . .	Describe here at the commencement of each bill the qualities of the materials and workmanship as set forth in the specification, as in the marginal headings here.
SAND . . .	
LIME	
MORTAR . . .	
BRICKS . . .	
BRICKWORK . .	

yds.	ft.	in.			£	s.	d.
				Then commence the various items of the bill, first the cubic quantities, then the superficial, &c., as in the abstract, thus :—			
44	6	0	cube.	General surface digging to a depth of 1 foot, and carting away.			
58	0	0	„	Trench digging and carting away 8 feet below surface.			

This should be carefully followed out for each trade, describing in the first page the qualities of material and workmanship as before.

In the bricklayers' bill is usually included the cost of—

Hoarding (mentioning length).

Water for the use of the works.

Fees to public officers, and the necessary notices.

Shoring and strutting.

The bills being set out in this form, and according to the order of the abstract, with, at the foot of the money column at the end of each trade, "Carried to Summary," in order that when the contractor has priced and moneyed out your quantities, he may then carry the sum of each trade to the

SUMMARY.

Then write your blank form of summary thus:—

ESTIMATE

for the erection of ________________________________

for ____

________________________________ Architect.

________________ 18

Summary.

	£	s.	d.
1. Excavator and Bricklayer . .			
2. Mason			
3. Carpenter, &c., &c., as described in the abstract			
Include per cent. upon the above amounts for Surveyor's charges for preparing quantities . . .			
Lithography, postage . . .			
Amount of tender . .			

Form of Tender.

——— hereby agree to execute the whole of the works required for the erection of the above buildings according to the plans and specifications, and to the entire satisfaction of the architect, at and for the sum of £ .

Contractor's signature ________________________

Date ________________

MODE OF MEASUREMENT IN THE CONTRACT FOR BUILDING THE HOUSES OF PARLIAMENT.

Extracted from PROFESSOR DONALDSON'S *Specifications.**

MASON'S WORK.

Cube stone.—If square, to be measured the net side when worked; but where the stone is not of a square form, to be measured to the size of a square stone of the least extent required; where the stones are of scantlings of six feet or upwards, to be measured separately from the ordinary cube stone.

Drafted backs.—The backs of the stones, where drafted, to be measured according to the surface actually shown.

Plain and sunk beds.—One plain bed only to be taken for each, except to mullions of windows, for which two beds are to be taken for each stone. Ordinary arch stones to be considered as having one plain bed and one sunk bed.

Plain and sunk joints.—Not more than one plain joint to be taken for each stone having one or more plain joints. All sunk joints to be taken as they occur.

Chiselled or rough faces to be measured to the size actually shown on the external surface.

Rough sunk to be taken when a large quantity of stone has to be removed; as in stop mouldings to sills, window heads, and other similar work.

Sunk, chiselled, or rubbed faces to be measured on the surface actually worked, adding the depth of the sinking.

Stopped sinking to be measured in such situations as do not permit the work to be carried straight through the stone, as in sills of windows and other similar work.

* Crosby Lockwood & Co., Publishers, London.

Preparatory labour, or plain face as bed, to be taken wherever it is necessary to produce a face, for the purpose of setting out underwork, as in tracery, heads, and other similar works. This is also intended to apply to mullions of windows, one side and one edge of which are to be taken plain as bed.

Sunk, chiselled, or rubbed face in short lengths, to hexagonal canopies, to be measured as they occur, including arrises.

Mouldings to be girthed and the surface shown; the top bed, if weathered, only to be measured as sunk faces.

Mouldings to panellings to be girthed, including the back of the panels.

Circular face to soffit of cusps to be measured the whole thickness of stone from back to front.

Circular face to soffit of cusps in panelling to be measured from the external face of the stone to the face of the panelling.

Sunk faces to tracery heads of panelling to be measured net on the face, adding the depth of the sinking from the external face.

Sunk face in margins for eyes to be measured the extrem length and width.

Circular sunk to rebated soffit of cusps to be measured from the external surface, adding the depth of the rebate.

Mouldings in tracery.—The extreme length of the straight mouldings in the tracery of the window heads to be measured through the mitres and junctions with other mouldings.

Throat to be measured per foot run.

Groove for cement to be measured per foot run.

Groove for metal sashes to be measured per foot run.

Rebate, not exceeding three inches girth, to be measured per foot run.

Mitres to sinkings to be numbered according to widths.

Mitres and returns to sinkings to be numbered according to the width of the sinking and length of the return.

Mitres to mouldings to be numbered according to the girth of the moulding.

Mitres to long intersections of cusped and other mouldings to be numbered according to the girth of the moulding and length of run.

Stopped ends of mouldings to be numbered according to girth of moulding.

Stopped ends of mouldings on splayed sills, and sills of panels, to be numbered according to the girth of moulding, and extreme length from top of sill to point of intersection.

Rough sinkings for cusped window heads and similar sinkings to be numbered, taking the average area of the sinking and the full thickness of the stone.

Holes punched to be numbered according to their area and depth.

Sinkings to form shingles to be numbered as they occur, according to length, width, and depth of sinking.

Notchings to form embrasures to be numbered according to their height, width, and depth of sinking.

Water joints to be numbered according to their projection.

Mitres to soffit of cusps in tracery heads of windows to be numbered according to their length and taken the full thickness of the stone.

Mitres to soffit of cusps in small tracery heads of panelling to be numbered according to their length measured from external face of stone to back of panelling.

Points to cusps in tracery heads of windows to be numbered according to their length, and measured the whole thickness between the sunk faces.

Points to cusps in small tracery heads of panelling to be

numbered according to their depth from sunk face to back of panelling.

Sunk and moulded eylets, each with one mitre and two long intersections, to be numbered according to extreme size.

Small sunk eyes to be numbered.

Cramps out of saw plate to be numbered according to length.

Cast iron cramps to be numbered according to length and thickness.

Plugs to be numbered according to length and size.

Small copper joggles and mortises to be numbered.

Joggles to vertical joints with pebbles in cement to be numbered according to size.

Pavings and landings to be measured per foot superficial.

Perforations to landings to be measured according to size and the thickness of the stone.

BRICKLAYERS' WORK.

The brickwork to be measured according to the number of bricks in the thickness of each wall, deducting all openings, except pargeted flues.

Cutting to be allowed for skew-backs of arches and surface cutting, but no cutting to be allowed for the interior of arches, except circular groined arches.

Pointing to soffits of arches and limewhiting to be measured per foot superficial.

Cement to back of parapets to be measured on the surface per yard superficial.

Rough splay to be measured per foot run, where it occurs.

Groined points to be measured per foot run.

Pointing to lead flashing to be measured per foot run.

Iron hooping to be measured per yard run, the quantity actually used.

CARPENTERS' WORK.

All framed timbers to be measured cube; the net quantity used for the work.

Fir or oak in plates, corbels, and lintels to be measured separately.

Battening for slanting to be measured on the surface of the roof per square.

Boarding for lead to be measured on the surface per foot superficial.

Valley and eaves boards, gutters, and bearers and boarding to sides of gutters to be measured per foot superficial.

Labour to rounding ridges, and labour to rebates to be measured per foot run.

Labour of splayed or bevelled edge of joists to be measured per foot run.

Tilting fillets and rolls of lead to be measured per foot run.

Rebated drips, rounded ends to rolls, short rounded rolls, and dovetailed cesspools to be numbered.

Timber, prepared in Kyan's tank, including carriage to and from, to be measured at per load.

Fixing bolts, straps, and cast iron heads to be numbered.

Fixing cast ironwork to be included in the price of the same by weight.

Wrought iron provided for bolts, straps, &c., to be charged according to the weight actually used.

Centring to brick arches—The quantity to be measured on the soffit of the arch at per square.

Flewing centring to pointed apertures to be measured per foot superficial.

Centring to stone arches to be measured on the soffit of the arch at per square.

SMITH AND FOUNDERS' WORK.

Cast-iron work to be provided, proved, and fixed complete, at per cwt. including patterns.

Wrought iron bolts, straps, and ties to be provided ready for fixing at per cwt.

Linseed oil rubbed into girders to be measured at per yard superficial.

SLATERS' WORK.

Slating to be measured on the surface at per square, allowing one foot for each eave, one foot for each valley and hip, and six inches for cutting to sides of dormers.

PLUMBERS' WORK.

Lead to be provided and laid by weight, which weight is to be ascertained by admeasurement when the work is completed, the weight per foot superficial being previously ascertained in the sheet.

Soldered angles to be measured per foot run.

Dots, lead plugs, lead wedges, and socket pipes to cesspools to be numbered.

Cast iron rain pipes to be measured per foot run.

Cast iron heads and shoes to be numbered.

Eaves gutter to be measured per foot run.

Bearings and collars to be numbered.

PAINTERS' WORK.

Painting to cast-iron work to be measured per yard superficial.

Painting to straps, bolts, &c., to be measured per foot run.

Painting bolts and heads to trusses to be numbered.

ESTIMATION OF QUANTITIES.

WEIGHT OF WROUGHT-IRON WORK.—(*Rule.*)—To find the weight of an irregular mass of wrought iron, find its content in cubic inches, and multiply by 0·278 for its weight in pounds, or by 0·000124 for its weight in tons; or,

(*Rule.*)—Multiply its content in cubic feet by 490 for the weight in pounds, or by 0·2143 for the weight in tons.

BAR IRON.—(*Rule.*)—To find the weight of a round bar, multiply the square of its diameter in inches by its length in feet and by 2·618 for the weight in pounds, or by 0·00117 for the weight in tons.

(*Rule.*)—To find the weight of an elliptical bar, multiply the conjugate by the transverse diameter in inches by the length of the bar in feet, and by 2·618 for the weight in pounds, or 0·00117 for the weight in tons.

(*Rule.*)—To find the weight of a rectangular bar, multiply its width in inches by its thickness in inches, by its length in feet, and by 3·334 for the weight in pounds, or by 0·00149 for the weight in tons.

(*Rule.*)—To find the weight of an iron plate, multiply its surface in square feet by its thickness in inches, and by 40 for the weight in pounds, or by 0·0178 for its weight in tons.

(*Rule.*)—To find the weight of angle iron, add together the breadths in inches of the two limbs measured outside, from which subtract the thickness of the metal in inches; multiply the remainder by the thickness in inches and by the length in feet, and by 3·334 for the weight in pounds or by 0·00149 for the weight in tons.

(*Rule.*)—To find the weight of a bar of irregular section (as the flange of a girder, a railway bar, &c.), multiply the sectional area in square inches by the length in feet, and by 3·334 for the weight in pounds, or by 0·00149 for the weight in tons.

(*Rule.*)—To find the weight of a sphere (as the two heads of hemispherical-headed rivets, governor balls, &c.), mul-

tiply the cube of the diameter in inches by 0·1454 for the weight in pounds, or by 0·000065 for the weight in tons.

(*Rule.*)—In estimating the weight of a plate girder, add about $3\frac{1}{2}$ per cent. of the weight of the girder for rivet-heads.

(*Rule.*)—To find the weight of a circular plate (as the end of a cylindrical boiler), multiply the square of its diameter in inches by its thickness in inches, and by 0·218 for the weight in pounds, or by 0·000097 for the weight in tons; or, multiply the square of its diameter in feet by its thickness in inches, and by 31·42 for the weight in pounds, or by 0·01402 for the weight in tons.

WEIGHT OF CAST IRON, BRASS, COPPER, LEAD, &c.—To find the weight of work in any of these metals, calculate it as for wrought iron, and then reduce to the metal of which it is made by one of the following factors:—

If the material is	steel,	multiply by	1·008
,,	cast iron	,,	0·915
,,	brass	,,	1·084
,,	copper	,,	1·150
,,	lead	,,	1·477

WEIGHT OF TIMBER WORK.—(*Rule.*)—To find the weight of timber flooring, multiply the breadth in feet by the length in feet, by the thickness in inches, and by one of the following factors, according to the material:—

If the material is	elm,	use	3·50 lbs.,	or	0·00156	tons
,,	yellow fir	,,	3·42	,,	0·00153	,,
,,	white fir	,,	2·97	,,	0·00132	,,
,,	dry oak	,,	4·85	,,	0·00216	,,

(*Rule.*)—To find the weight of timber beams, posts, and joists, multiply the length in feet by the breadth in inches and the depth in inches, and the product by one of the following factors:—

If the material is	elm,	use	0·292 lbs.,	or	0·000130	tons
"	yellow fir	"	0·285	"	0·000127	"
"	white fir	"	0.247	"	0·000110	"
"	dry oak	"	0·404	"	0·000180	"

AREA OF LAND IN CUTTINGS AND EMBANKMENTS.—(*Rule.*) —To find the breadth required for a cutting or embankment, multiply the depth of cutting or height of embankment by the inclination of the slope. Thus—

Let the cutting be 25 links in depth, and the inclination of the slope $1\frac{1}{2}$ horizontal to 1 vertical; the breadth required for one slope will be,

Ex.— $25 \times 1{\cdot}5 = 37{\cdot}5$ links.

If the depth is the same on both sides of the line, and we take the formation width at 50 links, the total width will be at this point,

$$37{\cdot}5+37{\cdot}5+50=125 \text{ links}=1{\cdot}25 \text{ chains.}$$

Let the depth of the cutting regularly diminish to 8 links at 22·53 chains from this point; the width for one slope will be,

$$8 \times 1{\cdot}5=12 \text{ links,}$$

and the total width at this point—

$$12+12+50=74 \text{ links}=0{\cdot}74 \text{ chain;}$$

the mean width of ground required in this length of 22·53 chains will be,

$$\frac{1{\cdot}25+0{\cdot}74}{2}=0{\cdot}995 \text{ chain.}$$

and the area of this piece of ground will be

$$22{\cdot}53 \times 0{\cdot}995=22{\cdot}417 \text{ square chains,}$$

which, divided by 10, gives

$$2{\cdot}2417 \text{ acres.}$$

If the widths are taken in feet instead of chains, proceed as above, but instead of dividing by 10 for acres, divide by 660.

Earthwork in Cuttings and Embankments.—(*Rule.*)—To find the content in cubic yards of the central part of a cutting or embankment (excluding the slopes), add together the depths of the cutting or embankment in feet at each end, multiply the sum by the width in feet, the length in chains, and by 1·223.

(*Formula.*)—Let d = depth in feet at one end,
D = depth in feet at the other end,
b = breadth in feet,
l = length in chains,
C = content in cubic yards,

$$C = 1{\cdot}223 \,.\, b.\, l.\, (d \times D.)$$

Let the depth at one end of a piece of cutting be 5 feet and at the other 12 feet, the breadth being 30 feet, and length 18 chains.

Ex.—

$$C = 1{\cdot}223 \times 30 \times 18 \times (5 \times 12) = 11227{\cdot}14 \text{ cubic yards.}$$

Should the breadth be given in chains instead of feet, replace the factor 1·223 by 80·667.

(*Rule.*)—To find the content in cubic yards of the two slopes, add together the depths of the cutting at each end in feet, square the sum, and from it subtract the product obtained by multiplying the heights together, multiply the remainder by the length in chains, by the horizontal distance to 1 vertical rise in the slope, and by 0·8148.

(*Formula.*)—The horizontal distance $= h$ to 1 vertical.

$$\left\{ C = 0{\cdot}8148 \,.\, l.\, h.\, (d+D)^2 - d\, D \right\}$$

Following out the former example, let $h = 1\frac{1}{2}$.

Ex.—$C = 0{\cdot}8148 \times 18 \times 1{\cdot}5 \;\left\{ 289 - 60 \right\} = 5037{\cdot}91$ cubic yards in each slope, the entire content of the excavation will be

$$5037{\cdot}91 + 5037{\cdot}91 + 11227{\cdot}14 = 21302{\cdot}96 \text{ cubic yards.}$$

(*Rule.*)—To find the solid content of any body of uniform section throughout, multiply its sectional area by the

length of a line passing through the centre of gravity of all the sections.

(*Formula.*)—

Let a=sectional area.

l=length of line passing through centre of gravity of sections,

C=solid content,

$C=a.\ l.$

Suppose the solidity of the rim of a wheel is required, the internal diameter being 5 inches, and the external diameter 7 inches, and the rim 2 inches broad (the rim will be 2 inches × 1 inch), the radius of the circle passing through the centre of gravity of the section will be

Ex.— $2{\cdot}5+5=3$ inches,

and its circumference $18{\cdot}85$ inches;
the sectional area $= 2 \times 1 = 2$ square inches,
and the solid content of the rim

$$C=2\times18{\cdot}85=37{\cdot}7 \text{ cubic inches.}$$

Suppose the solid content of a cone is required, such cone being generated by the revolution of a right-angled triangle revolving about its perpendicular, the perpendicular being 8 inches and the base 9 inches in length.

Ex.—The distance of the centre of gravity of the triangle from the axis of rotation

$$=3 \text{ inches};$$

hence the length of a line passing through such centre

$$= 18{\cdot}85 \text{ inches.}$$

The area of the triangle is

$$9\times\frac{8}{2}=36 \text{ square inches.}$$

The content of the cone is

$$C-36\times18{\cdot}85=678{\cdot}6 \text{ cubic inches.}$$

(*Rule.*)—To find the area of a superficies generated by

the motion of a line, multiply the length of the line passing through the centre of gravity of the generating line in every position by the length of the generating line.

(*Formula.*)—

Let l=length of line passing through the centre of gravity of generating line,

L=length of generating line,

A=area of surface.

$$\underline{A = L.\ l.}$$

Let the area of a circle be required, the generating line (radius) being 6 inches long, the circle passing through the centre of gravity of such line will be

3 inches radius=18·85 inches circumference.

Ex.— $A = 18{\cdot}85 \times 6 = 113{\cdot}1$ square inches.

PRICES THAT MAY BE CONSIDERED AN AVERAGE FOR A PLAIN VILLAGE CHURCH.

	s. d.
Dig, throw out, fill in, and ram ...	1/- yard cube.
Concrete in foundations	7/6 „
Do. 5 in. thick under floor... ...	-/9 ft. super.
Flint walling	100/- per rod cube.
Double slate damp course	3/- yd. super.
4 in. socket-jointed drain and digging ...	-/8 ft. run.
Red tile floor, 4½ in. square	14/- yard super.
Chancel floor with encaustics	18/- „
Bath stone dressings (stone and labour)	4/- ft. super.
Tracery, 9 in. thick	4/- „
Do. 8 in.	3/6 „
York steps	5/- foot cube.
2 in. hearths	1/- ft. super.
Portland step, solid	8/- ft. cube.
2 in. step	1/4 ft. super.
Timbers, not wrought	3/6 ft. cube.
Timber, wrought and framed	3/9 „
Floor joists	2/6 „
1¼ yellow deal, ploughed and tongued floor	42/- per square.
Nave deal seats	2/4 ft. run, including ends.
Tiling, including laths	44/- square.
Tile ridge	2/6 ft. run.
Plastering to walls	1/4 yard super.
Do. to partitions	1/7 „
Do. between rafters	1/9 „

	s. d.
Eaves spouting	-/8 ft. run.
Stopped ends, 6d.; outlets, 1/9 each.	
Saddle bars...	1/- ft. run.
Eyes for stanchions	-/3 each.
Stanchions	1/- ft. run.
Fleur de lis termination	1/6 each.
Casement in vestry	20/-
Lead in gutters	32/- per cwt.
Glazing in small squares and quarries, Cathedral glass	2/- ft. super.
Paint ironwork four times	1/6 „
„ woodwork do.	1/- „
Staining to roofs	-/8 „
Do. seats	-/6 „

GENERAL MEMORANDA AS TO THE STRENGTH AND WEIGHT OF MATERIALS.

Wrought iron should not be strained beyond 10 tons per square inch, and deal 2½ tons per square inch.

An ordinary round rod of wrought iron, 1 inch in diameter, bears tensilely 16 tons, and weighs 8 lbs. per yard.

For a round rod of any diameter, the square of the diameter taken in quarter inches is the breaking weight in tons: half this quantity is the weight in lbs. per yard, thus:—

The breaking weight of a round bar 5 inches, or twenty ¼ inches in diameter, will be 20 × 20, or 400 tons, and the actual weight will be half 400, or 200 lbs. per yard.

A rod will be perceptibly damaged by half this strain, which can never be safely exceeded, one-third being sufficient in practice.

The strength of a chain cable is thus easily arrived at, the strength of a link being double that of the bar from which it is forged.

It is usual technically to denominate chains by their diameter; thus, a ⅝th chain is a chain made from a bar ⅝th inch in diameter.

The following approximations will be found very convenient in estimating the weight and strength of chains, the ultimate tensile strength of the material being taken at 16 tons per circular inch, or 20 tons per square inch of section.

1. The square of the diameter in eighths will be the weight of the chains in lbs. per fathom.

2. The square of the diameter in eighths divided by 2 will be the breaking weight in tons. Thus the breaking weight of a $\frac{5}{8}$ chain will be half 25 tons $= 12\frac{1}{2}$ tons; and the actual weight will be 25 lbs. per fathom of six feet.

A chain will be perceptibly damaged by half this weight, which can never be safely exceeded, one-third being sufficient in practice.

Transverse strength of a slab of slate from the Penrhyn quarries.

A slab of slate 2 feet 10 inches broad, 4 inches thick, and 4 feet between the bearings, failed with $24\frac{1}{4}$ tons distributed over 15 inches at the centre of the span.

A slab of cast iron of the same dimensions would securely support five times as much, and would be two and a half times as heavy. This material forms a valuable flooring for bridges.

Experiments made on beams of American red pine timber of the scantling of 12 inches square, and 17 feet long, the distance between the bearings 15 feet.

They were laden by actual weight suspended on a scale from the centre of the beams. (See Nicholson's Dictionary, p. 479.)

Dry timber from the butt end of the balk:—

Weight of beam, 5 cwt. 2 qrs. 5 lbs., or 36·5 lbs. per cubic foot.

Breaking weight, 14·82 tons.

Dry timber from the top end of the balk:—

Weight of beam, 5 cwt. 17 lbs., or 33·9 lbs. per cubic foot.

Breaking weight, 13·24 tons.

Table of the comparative time of the Run of Water through brick drains and glazed pipes.

INCLINATION.	DEPTH OF WATER.	TIME THROUGH GLAZED PIPES.	TIME THROUGH BRICK DRAIN.
Level	5	38	50
2 inches in 50 feet	4½	16½	25
2¾ „	5½	19	27
1¼ „	3	18	26
½ „	3½	25	36
3¼ „	4	15	22
1¾ „	6	13	21½

Time occupied by the passage of equal quantities of water through similar lengths, and with the same inclinations:—

Along a straight line ... ... 90 seconds.
With true curve ... ... 100 „
With turn at right angles ... ... 140 „

Experiments on the Strength of Beams supported on one end.

KIND OF WOOD.	Specific gravity.	Length in feet.	Breadth in inches.	Depth in inches.	Deflection at the time of fracture, in inches.	Weight that broke the piece, in pounds.	EXPERIMENTALIST.
English oak ...	·922	4	2	2		266	Beaufoy.
Dantzic oak ...	·854	4	2	2		196	Do.
Beech	·700	3	2	2	11	401	Barlow.
Ash	·730	2	1	2	6	321	Do.
Teak, old dry ...	·606	5	2	2	12½	257	Do.
Virginian yellow pine	·522	5	2	2	11¾	147	Peake and Barralier.
Canadian white pine	·618	5	2	2	18¾	122	Do.
Pitch pine ...		4	2	2		270	Beaufoy.
Larch, dry ...	·526	5	2	2	16¼	162	Peake and Barralier.
Red pine	·544	2	3	3		1630	Do.
Riga fir	·537	4	2	2		210	Beaufoy.

Experiments on the Strength of Woods supported at both ends.

KIND OF WOOD.	Specific gravity.	Length of feet.	Breadth in inches.	Depth in inches.	Deflection at the time of fracture, in inches.	Weight that broke the piece, in pounds.	AUTHORITIES.
English oak, young tree	·863	2	1	1	1·87	482	Tredgold.
Do. medium	·748	2·5	1	1		289	Ebbels.
Do. green	·763	2·5	1	1		219	Do.
Beech, medium quality ...	·690	2·5	1	1		271	Do.
Alder	·555	2·5	1	1		212	Do.
Plum tree ...	·648	2·5	1	1		243	Do.
Chestnut, green ...	·875	2·5	1	1		180	Do.
Ash	·753	2·5	1	1	2·38		Tredgold.
Elm, common ...	·544	2·5	1	1		216	Ebbels.
Mahogany, Spanish seasoned ...	·853	2·5	1	1		170	Tredgold.
Do. Honduras, seasoned ...	·560 ·920	2·5	1	1		255	Do.
Walnut, green ...	·374	2·5	1	1		195	Ebbels.
Poplar, Lombardy		2·5	1	1		131	Do.
Teak	·744	7	2	2	4·00	820	Barlow.
Willow	·405	2·5	1	1	3·	146	Tredgold.
Birch	·720	2·5	1	1		207	Ebbels.
Riga fir... ...	·480	2·5	1	1	1·15	218	Tredgold.
Norway fir ...	·639	2	1	1	1·125	396	Do.
Scotch fir, English growth ...	·529	2·5	1	1	1·75	233	Do.
Christiania white deal	·512	2	1	1	·937	343	Do.
Spruce fir, British growth ...	·555	2·5	1	1		186	Ebbels.
Larch, medium quality	·622	2.5	1	1		223	Tredgold.
Red pine ...	·54	4	3	3		3780	Fincham.
Yellow pine ...	·439	4	3	3		2756	Do.

TRANSVERSE STRENGTH OF BEAMS.

The transverse strength of rectangular beams, or the resistance which they offer to fracture is as the breadth and square of the depth; therefore, if the two rectangular beams have the same depth, their strengths are to each other as their depths; but if their breadths are the same, then their strengths are to each other as the squares of their depths.

The transverse strength of square beams are as the cubes of the breadths or depths. Also, in cylindrical beams the transverse depths are as the cubes of the diameter.

Thus, if a beam that is one foot broad and one foot deep support a given weight, then a beam of the same depth and two feet broad will support double the weight.

But if a beam be one foot broad and two feet deep, it will support four times as much as a beam one foot broad and one foot deep.

If a beam one foot square support a given weight, then a beam two feet square will support eight times as much. Also, a cylinder of two inches in diameter will support eight times as much as a cylinder one inch in diameter.

RESULT OF EXPERIMENTS

Made with actual weight of Materials used in the Britannia Bridge, January, 1848.

Brickwork.—Upon 9 inch cubes of brickwork set in cement. In five experiments the average crushing weight was 521 lbs. per square inch; or 33½ tons per square foot, equal to a column of 583·69 feet high of such brickwork.

The three last cubes continued to support the weight,

although cracked in all directions; they fell to pieces when the load was removed. All the brickwork began to show irregular cracks a considerable time before it gave way.

Sandstones.—Upon 3 inch to 9 inch cubes of sandstone, in five experiments, varying from quite dry to "made very wet," the average crushing weight was 2185 lbs. per square inch.

All the sandstones gave way suddenly, and without any previous cracking or warning.

Average weight, 130 lbs. 10 oz. per cubic foot, or 17 feet per ton.

Limestone.—Upon three inch cubes of Anglesea limestone, in four experiments, the average crushing weight was 7579 lbs. per square foot. Weight of the material 165 lbs. 5 oz. per cubic foot, or 13½ feet per ton.

The weight required to crush this limestone is 471·15 tons per square foot, equal to a column 6433 feet high of such material.

All the limestones formed perpendicular cracks and splinters a considerable time before they crushed.

To find the weight of any quantity of wrought iron, wrought and close hammered, reduce the quantity into cubic inches, and multiply the product by 28; cut off the two figures to the right, and the remainder is the weight in pounds.

To find the weight of cast iron, proceed as above, but multiply by 27 instead of 28.

Or,—Multiply the number of eighths of an inch in the section, and divide by 19.

Example: A bar of iron 3¼ inches by 1½ inches.

The number of eighths of an inch in 3¼ are 26.

" " " " 1½ " 12.

12 × 26 = 312 thus: 19)312(17 lbs. 9oz. to 1 foot.

```
19)312(17
   19
   ---
   142
   133
   ---
     9
```

Table showing the weight of Metal Plate, per square foot.

Inches.	Wrought iron.	Cast iron.	Cast copper.	Cast brass.	Cast lead.	Cast zinc.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1	2·5	2·3	2·9	2·7	3·7	2·3
2	5·1	4·7	5·7	5 5	7·4	4·7
3	7·6	7·0	8 6	8·2	11·1	7·0
4	10·1	9·4	11·4	11·0	14·8	9·4
5	12·7	11·7	14·3	13·7	18·5	11·7
6	15·2	14·0	17·2	16·4	22·2	14·0
7	17·9	16·4	20·0	19·2	25·9	16·4
8	20·3	18·8	22·9	21·9	29·5	18·7
9	22·8	21·1	25·7	24·6	33·2	21·4
10	25·4	23·5	28·6	27·4	36·9	23·1

Table showing the value of 1 cwt. of Lead, from ⅛ of a Penny per lb. to Sixpence.

d.		£	s.	d.	d.		£	s.	d.
⅛	is	0	1	2	3¼	is	1	10	4
¼	„	0	2	4	3½	„	1	12	8
½	„	0	4	8	3¾	„	1	15	0
¾	„	0	7	0	4	„	1	17	4
1	„	0	9	4	4¼	„	1	19	8
1¼	„	0	11	8	4½	„	2	2	0
1½	„	0	14	0	4¾	„	2	4	4
1¾	„	0	16	4	5	„	2	6	8
2	„	0	18	8	5¼	„	2	9	0
2¼	„	1	1	0	5½	„	2	11	4
2½	„	1	3	4	5¾	„	2	13	8
2¾	„	1	5	8	6	„	2	16	0
3	„	1	8	0					

Table showing the weight per superficial foot of Lead, from $\frac{1}{16}$ of an inch thick.

Thickness. Inches.	Weight. lbs.	Thickness. Inches.	Weight. lbs.
$\frac{1}{16}$	$3\frac{3}{4}$	$\frac{1}{4}$	$14\frac{3}{4}$
$\frac{1}{12}$	5	$\frac{1}{3}$	$19\frac{3}{4}$
$\frac{1}{10}$	6	$\frac{1}{2}$	$28\frac{3}{4}$
$\frac{1}{8}$	$7\frac{1}{2}$	$\frac{3}{4}$	$44\frac{1}{4}$
$\frac{1}{6}$	10	1	59
$\frac{1}{5}$	12		

Specific gravity of lead, 11·325. Weight per cubic foot, 708 lbs.

SHEET LEAD.

Table showing how many feet superficial a cwt. of sheet lead will cover on a flat roof or gutter, &c., from 4 lbs. to 12 lbs. per foot; the value of each superficial foot or square, according to the several weights,—viz. at 3¾d. per lb., or £1 15s. 0d. per cwt. for all lead under 7 lbs. per foot superficial; and 3½d. per lb., or £1 12s. 8d. per cwt. for 7 lbs. per foot superficial, and including labour, solder, &c.

Weight per ft. superficial.		ft.	in.	Expense per foot superficial. £	s.	d.	Expense per square on 100 feet superficial. £	s.	d.
4	Milled lead £1 15s. per cwt. or 3¾d. per lb.	28	0	0	1	3	6	5	0
5		22	5	0	1	$6\frac{3}{4}$	7	16	3
6		18	8	0	1	$10\frac{1}{2}$	9	7	6
7	Cast lead, £1 12s. 8d. per cwt., or 3½d. per lb.	16	0	0	2	$0\frac{1}{2}$	10	4	2
8		14	0	0	2	4	11	13	4
9		12	$5\frac{1}{2}$	0	2	$7\frac{1}{2}$	13	2	6
10		11	3	0	2	11	14	11	8
11		10	2	0	3	$2\frac{1}{2}$	16	0	10
12		9	4	0	3	6	17	10	0

Table showing the weight of Lead Pipes in lbs.

Bore. inch.	Length. ft.	Common. lbs.	Middling. lbs.	Strong lbs.
½	15	16		
¾	15	24	27	30
1	15	30	40	43
1¼	12	36	44	53
1½	12	48	56	67
2	10	56	70	83
2½	10	70	89	100

SUPERVISION OF WORKS, AND THE DUTIES OF THE CLERK OF THE WORKS.

I HAVE endeavoured to assist the architect in his specification, estimate, quantities, and construction, and we have now arrived at that happy period when the work he has done is to bear fruit in some new building for the convenience (let us hope) of those who are to use it.

A few general words as to the duty of an architect in this stage of his labours may be here intruded.

We will just glance backward for a moment at the work we have done, and the work we have left undone.

Our client, being a very reasonable man, has listened to our representations, and has not insisted, further than the first interview, in trying to get twice as large a building for the money he wishes to spend as it will be possible to give him.

The drawings are made, each drawing has a legible and correct scale upon it; and, in order that the contractor or quantity surveyor shall be certain about the character of the design, details to a large scale have been drawn to accompany the small scale drawings.

The specification has been carefully drawn up, describing the materials, or construction; and the value of the fittings that cannot be described or shown otherwise.

The amount of the lowest tender is fair; that is to say, if it gives a fair profit for the work to be contracted for, and

the contractor understands his business, and wishes to do the work well.

The contract that has been drawn up and signed gives the proper amount of power to the architect in the selection of materials, and the rejection of that which is improper, and he is also restrained from recklessly ordering extras.

The "happy hunting grounds" described in the last few paragraphs are, I have no doubt, in existence somewhere; but there are not many inhabitants of that country; nor could there be: competition would soon destroy such a golden age, as it is fast doing so here.

But if "'tis not for mortals to achieve success," they can, at any rate, try their best to obtain that which is the best state of things; and that is the reason, with a pen dipped in rose madder, I described such happiness.

My imagination refuses to reflect, and my pen to write, a continuation to the before-mentioned story; or else I would describe how the building was satisfactory to every one. The design pleased everybody—even the designer; the work was carried out for the sum originally proposed, and they all lived happily ever afterwards.

I will therefore suppose that the foundations are difficult, and it is necessary that some parts of the footings should be carried down more deeply than those shown on the drawings. This can be provided against by a clause in the specification requiring that the contractor should send in with his tender in the schedule of prices which he is required to furnish, his price per cubic yard for any more that will be required: this should be measured at the time, so that no dispute may occur at the completion of the work; and at the same time should be noted any part of the foundations where they do not go down so deep as the drawings provided. One thing may balance another;

if not, and the employer has bound you to a certain sum some saving must be studied in another part of the structure.

If this principle is carried out throughout the building, many of the difficulties and troubles, the recriminations and heartburnings, the appeals to law and "my solicitor," might be saved.

No architect should neglect to bear in mind that, although it is his work and his duty to erect as good a building as possible for his client, the contractor has entered upon the work in order also to obtain something; and his (the architect's) duty is to see that no unfair advantage is taken on either side.

When the work is of sufficient importance; and, indeed, wherever possible, a clerk of the works should be engaged to watch the work in the interest of the employer, and that is the only way in which a perfectly sound building can be ensured; because, although the contractor may have every wish to do well, the thousand and one questions that are constantly arising as to the meaning of drawings require a skilled interpreter to be always on the spot.

To be an interpreter of the drawings, and a witness that the materials are those intended to be used when the contract was signed, are the sole duties of the clerk of the works, and very onerous duties they are if properly performed. They require an equable temper, a thorough practical education in all branches of the building trades, and a thorough knowledge of the meaning of drawings.

In order that the architect should know exactly the state of the building and its progress, the clerk of the works should be furnished with some blank forms, somewhat like this one subjoined:

<table>
<tr><td colspan="5">Statements of the Works at   for the week ending   day of   18   .</td></tr>
<tr><td>The Weather.</td><td>Drawings Required.</td><td>State of the Work.</td><td>No. of men.</td><td>Workmen employed at</td></tr>
<tr><td rowspan="2">Sunday.
Monday.
Tuesday.
Wednesday.
Thursday.
Friday.
Saturday.</td><td></td><td></td><td>Digger - -
Mason - -
Waller - -
Bricklayer -
Carpenter -
Joiner - -
Slater - -
Plasterer -
Plumber - -
Smith- - -
Painter - -</td><td></td></tr>
<tr><td colspan="2">General Remarks.</td><td>Disbursements.</td><td>Sundries.

Signature.</td></tr>
</table>

These forms should be filled up and forwarded to the architect's office at the end of each week; and there, if docketed, will be a record of the progress of the work, and enable him to understand what may be required, and how to time his visits of inspection.

I have heard many theories as to what trade a clerk of the works should have been brought up to. Joiners are more frequently chosen because their work is more shown in the finishing of the building, and they are, as a rule, a very decent body of men, with more general information than some other trades; but they cannot, of course, unless under exceptional circumstances be undoubted judges, say, as to the quarry bed of a stone, or the quality of bricks.

It is better to choose the clerk of the works with reference to the particular work for which he is required. For a stone-built church a mason would be, probably, the best man; for the majority of dwelling-houses, a joiner: but it seems to me that a man who has been brought up for the general supervision of a building, over all the trades, is more likely to be a trustworthy foreman, than one who has, possibly, contracted a restricted class or trade prejudice.

WARMING AND VENTILATION.

In the title of this article is summed up the whole duty of an architect. We require buildings to shield us from the weather (our persons or our goods); and, this object being attained, we should so ventilate our work that the inhabitant or occupant should breathe pure air.

If this proposition be taken for granted, the importance of the subject cannot be over-rated; and if proper attention could be given to it in every building, a sneer at architects, which is the favourite method of treating the matter in the public press, would lose its sting.

Every building requires drainage for sewage matter and other excreta, the ventilation of which is as important to health as any other arrangement, but how often is this left to "take its chance." Every apartment in a house requires that the air should be frequently changed; but if the joinery were perfect this could not be had in most cases, for the only currents of fresh air are under the doors and between the window sashes.

To take the case of an ordinary town house, warmed by means of open grates, the following precautions should be considered as necessary, and as much care should be exercised as in keeping out the damp.

First, for the drainage, not only should all the exits be carefully trapped, but they should be periodically examined, in order to ascertain whether they are in good working

order; and below the trap, in every case, there should be an air shaft carried up above the level of the roof to give an outlet to the sewer gas which collects wherever there is a space. This shaft is useful in several ways; the sewer gas, if warmer than the outer air, will rise and escape, and dissipate in the open air, and if it is not warmer, then a down-draught is created every time the plug of a W.-C. or other exit is set working, and so prevent the upward rush of air that otherwise occurs every time that the trap is opened or in active use.

When gas is used, above every burner, or arrangement of burners, there should be a trumpet-mouthed exit for the heated spent air: this should be conducted horizontally between the ceiling and the next floor into flues specially arranged and, for the sake of convenience, built into the smoke stack. This should be considered indispensable wherever gas is used; no system of gas-lighting should ever be considered without it, and no ventilation is more perfect, because the heated air forms its own draught, and, in fact, sets itself in motion the moment the gas is burning, whilst at the same time, as the heated air escapes, the air in the room rises and any arrangements for the inlet of fresh air are put in operation. The top of each of these flues, or spent air escapes, should be covered with a capping, which, whilst it prevents the outer air from blowing down, at the same time leaves a ready escape for the spent air.

The next arrangement in importance for a town dwelling-house is warming, and as this may, and should, be also the active principle in the ventilation of a dwelling-house, I will consider both subjects at the same time.

Firstly, an open fire being taken for granted, how should it be constructed so that it should give out a proper amount of heat for the quantity of fuel? Those parts of a fireplace, such as the bars, which have to stand rough

treatment whilst in a state of heat, must be made of metal; but, as most metals are good conductors of heat, the grate and the adjacent parts should be of a non-conducting substance, so that no more of the heat than is necessary should be absorbed, and for this purpose fire-clay, moulded in the various forms for the back and sides, should be used. Then, in order to further economize the heat, a hollow chamber should be formed surrounding the whole of the fireplace; and, if fresh air be introduced into this chamber, it can, after being heated, be brought into the room.

Fresh air should also be brought by means of air channels under the grate, so that when the column of air laden with smoke, which, being warmer than the outside air, rises in the flue and is called a draught, it may be readily fed, and if the room be inhabited by over-anxious people or invalids, who close the natural inlets of air, the doors and windows, the fire will burn by the free admission of that which is as necessary to it as fuel, and, indeed, is part of the composition of fire itself.

I have here described in general terms the systems adopted by many makers of stoves and grates, and the advertising columns of the building papers will show many that are all arranged on the principles above set forth. I generally advise the adoption of Barnard, Bishop, and Barnard's, or Boyd's, having found them satisfactory, but I do not mention these names in order to draw invidious comparisons with other makers, who may be quite as good in principle and workmanship.

In situations where the back of the grate, or chimney back, is placed towards a passage or corridor, great comfort in the house, and economy of fuel, may be attained by forming a valvular grating connecting with the hollow back, thus warming two apartments with one fire.

It is essential, in all houses where comfort is studied, that it should be possible to make the hall and passages, although not so warm as the apartments, at least some degrees above the outside air in cold weather. Surely nothing can be more dangerous to delicate persons than the custom of super-heating the rooms and leaving the passages, and even the bedrooms, to take care of themselves; the icy stagnation of the air that is felt in houses that are left in this manner, is only to be once felt to be ever afterwards remembered. An effectual method of arranging this is by means of hot-water pipes, fed from a boiler in connection with the kitchen range; and if this be considered whilst the hot-water supply to the lavatory and the bath-room is being fixed, the extra expense is very slight.

Where the hall is in a central position a small Gurney stove will be found a very great acquisition to the comfort of the house. Care should be taken wherever there is a fire to obtain for it, by means of special channels, a current of fresh air; if this be done the fire, in all cases, will help to ventilate the apartment in which it is burning.

In cold and exposed situations, when it is impossible to keep even a small casement open, if double sashes be provided the outer air may be admitted without any perceptible draught by slightly opening the bottom light of outer sash and the upper light of the inner sash.

In rooms with a warm aspect a small casement or ventilator should be provided, in order to admit the air when it is not desirable to open the windows.

The ventilation of all the timbers of a building should also be carefully arranged by gratings, placed so as to admit a thorough current of air in the space under the lowest wooden floor and between all the ceilings of the ceiled rooms and the floor above.

The ventilation and warming of public buildings, such

as halls of meeting, churches, hospitals, or schools, where large numbers of persons assemble in the daylight, require different treatment to theatres and other places of amusement, where they are in most cases used at night, and require no warming arrangements.

In the former class of buildings the first necessity for the warming is a good and well-ventilated chamber for the heating apparatus, the next is the choice of system to be used, whether by steam, hot water, or hot air, or a mixture of the two systems.

The systems of heating by hot air are the least expensive in execution, the simplest being to sink, under the level of the floor, a furnace or stove, the chamber being covered by means of perforated gratings; the smoke-flue is then carried in a trough through the building in order to economize the heat, and the smoke is then discharged at some convenient distance by means of an upright flue.

In the more elaborate systems of heating by air, the hot air is discharged at various points of the building, either at the level of the floor or by means of gratings, at any desired level above the floor; in all cases where this plan is adopted the gratings should be made to close by some sort of valvular arrangement, in order that, if it be necessary, the heat can be economized, or directed into any portion of the building where it may be required.

The hot-water system is much more effective than the hot air, but is much more expensive. In the best systems I have had under my notice, the pipes filled with water are coiled in the furnace, and, being carried throughout the building required to be heated, return again into the furnace, so that no boiler is required, and the water, being continually re-used, soon loses any sediment it may have had originally; then, by means of a waste and escape valve at the highest point of the piping, the whole

is very easily kept in order. The two dangers of this system are, that the escape-valve should become out of order, and that the pipes, in course of time, may fail from the constant pressure; but this does not appear more than one of the objections that pertain to any system. Nothing can be kept in continual working order without proper and periodical inspection, from the simple precaution of inspecting and cleaning the roof-gutters to the examination at stated intervals of a steam-engine boiler.

The plan of carrying the pipes through the building in a sunken chamber or trough, although convenient, and more sightly than keeping them above the floor level, is certainly wasteful of a great quantity of heat, because the air heated by the under sides of the pipes being in most cases confined within a narrow limit, cannot radiate its heat, and, therefore, at least one-third of the power is wasted; but, when appearance is to be studied, I should certainly recommend the trough system.

In buildings such as schools, where the divisions into apartments are not more than twenty feet wide, there appears to be no better system of warming than by means of the ventilated open fireplace,—and, indeed, this has been always recommended by the Committee of the Privy Council on Education.

Of course where there are many fires to be lighted and attended to, the labour is very much greater than the one furnace, which is attended to by a responsible person; but in public schools, where there are so many young hands who ought to be taught the proper methods of laying, lighting, and keeping up a fire, this should be no objection, unless the pupils are supposed to go to school to merely learn out of books.

Wherever pipes are used for the conveyance of heated air or water, they should always be so placed that the dust collecting on them be easily cleaned off them,

especially when they are under a floor; much of the offensive smell that is complained of from heated pipes will be found, on examination, to proceed from matter scraped from the feet of persons passing over them.

Gas stoves I merely mention in order to condemn as expensive, unhealthy, and inefficient, and never to be used except where no other plan can be adopted.

In the ventilation of buildings that are used only for gaslight representations, there should be no difficulty if the rules laid down for a dwelling-house be observed: no gas-burner should be put except above it could be placed a flue to carry off the spent air that is the result of the combustion. This should be as carefully provided as if each burner were a grate evolving visible smoke. I have had no practical experience of them, but according to the descriptions and theory, it seems to me that the system called Tobin's is one of the most perfect that has been discovered for introducing fresh air into any place that is thronged with persons. It consists in placing vertical tubes to about the level of the head of an adult, having a wide mouth bending into the room, and an inlet from the outer air; this, acting upon the syphon principle, being once set at work by the action of the gas, and the calls for more air which each burner gives out, would produce a constant upward and imperceptible current of air.

In all systems of ventilation one thing is certain, that openings to let in fresh air, and openings to let out foul or spent air, are useless unless there is united action between them. If the foul air, being driven upwards by its being warmer than the fresh air, comes across a current of cold air, it is immediately cooled, and being of greater specific gravity than fresh air, it sinks again; so that there is only the choice of evils—whether you will take your poison hot or cold!

No general directions that will be equally applicable can be given. All I have endeavoured to do is to put together that which I have found in my experience to be the principles to be observed. That plan which would thoroughly ventilate a building placed on a high hill would certainly not answer in a warm valley. The thickness of the walls must always be taken into account in the plans of warming; thin walls take up and dissipate so much heat that thick walls will contain and return to the interior.

In all cases where possible, let the arrangements for the lighting, warming, and ventilation be considered at the same time; so that, if even they cannot be carried out simultaneously, it will be evident to your successor what were your intentions.

Ventilate all the drains to the outside of the building.

Supply fresh air to all places where foul is being consumed.

Carry off the spent air of gas by means of flues specially arranged; and where the flues are necessarily of so great a length that the air within it will cool so much as to check the upward current, insert a small gas jet in the flue, that will start the current and keep up the circulation.

Remember that a cold draught of air brought down upon the head is not only dangerous, but is probably not ventilation,—it is very probably only the foul air, cooled by friction with the outer air, descending to be *réchauffé*, and again consumed.

Let the inlet for supplying fresh air be in direct communication with the outer air, as no ventilation from one apartment to another can be efficient.

CONCRETE.

I EXTRACT the following remarks from the Transactions of the Royal Institute of British Architects, 1835 to 1836: "A Prize Essay on the Nature and Properties of Concrete," by G. Godwin, Esq., F.R.S., F.S.A.

"The concrete now generally employed is compounded of Thames ballast and Dorking lime, in certain proportions, varying according to the opinion of the user and the goodness of the materials, from one of lime and four of ballast, to one of lime and twelve of ballast. They are sometimes mixed together, slaked as mixture, and thrown into the foundation from a certain height: sometimes the ballast is laid on the site of the intended erection, and the lime poured over it in the shape of grout; whilst at other times the spaces to be concreted are filled with water, and the lime and ballast being mixed in proper proportions are thrown into it dry.* Instead of gravel, Kentish rubble and broken pieces of granite, properly grouted, have been most extensively employed, more especially by Sir John Soane, who has used a preparation of this sort for most of the public buildings in Westminster executed under his direction; viz.: at the Law Courts, the additional buildings to the House of Lords, the Library of the House of Commons, the Board of Trade

* The first of these methods is that which is now most commonly employed.—F. R.

and Privy Council offices, the State Paper office, and others. The foundations of these edifices were formed of granite or other hard stone broken in small pieces (none exceeding the size of an ordinary hen's egg), and laid in layers closely rammed, and grouted every third layer with a grout composed of Dorking lime and sharp river sand; other layers of similar pieces of stone were then laid, and rammed and grouted as before, and so the operation was repeated until the required thickness was attained. Upon the top of the mass thus formed there is usually a tier of York landings, connected by a chain bar, from which arise the walls. . . . The buildings appear to stand well. . . .

"Notwithstanding the high, and deservedly high, authority of Sir John Soane's name, to me there seem several objections to the adoption of this method.* In the first place, from an examination I find that into many of the interstices, unless the work is executed with greater care than can in all cases be ensured, necessarily occurring between the stones, and which are many more than can possibly exist when the stones used are of a variety of sizes, intimately mixed as in ballast, the grouting does not penetrate, whereby the solidity of the mass is greatly interfered with; secondly, by the after ramming much injury accrues to the lower stratum, by that time perfectly *set*; and, thirdly, the expense." . . .

I have quoted the foregoing remarks, although they are treating in great measure of a practice that is now little used, as it sets forth so clearly the ill effects of such a mode of construction, by layers, and ramming—rending to

* The experience of the last thirty-five years fully bears out the opinion here given, and proves the care and scientific insight of the author of this paper.—F. R.

pieces with repeated blows, a substance that ought to be of all others homogeneous, after it has cemented together.

"In order properly to apportion the quantity of lime necessary to be used with the ballast, it will be well if you ask yourself this question: What are you in reality doing when forming a mass of concrete? or, rather, what ought to be done? To this the answer must be, a stone wall; in a manner, it is true, possessing advantages peculiarly its own, but still a stone wall. The pebbles, then, are *the materials with which it is to be built*, and must be regarded only in that light, so that in considering the quantity of lime necessary to be added in order to form a *proper mortar* wherewith to unite them, regard must alone be had to the sand contained in the ballast, and according to the quantity and quality of that ingredient must be apportioned the lime. It is true, that upon the proportion borne by the pebbles to the mortar, the strength and goodness of the concrete materially depend; but this, except under peculiar circumstances, must but little interfere with the preparation of the mortar; it is another question, separately to be considered.

"Now, practice, and a variety of experiments, have shown, that Dorking stone lime, being ordinarily good, will form a most excellent mortar when mixed with three times its own quantity, by measure, of sand; and, although it is quite certain that if it be well burned, ground, and used hot—and this *it must always be* for concrete—it will make excellent mortar when mixed with four of sand, even better, if the lime be powerful, than with less, this may serve as a generally admitted good proportion. With respect to the amount of stones essential to a good concrete, it is generally maintained by those practical men

who have thought upon the subject—unfortunately but few—that it should be double that of the sand by measure, and my own experience fully bears out this belief. Three masses of concrete equal in bulk, were formed in pits prepared for them. No. 1 was compounded of screened stones well grouted with lime water, no sand or small stone was present; No. 2, of four parts stone, and one of sand; No. 3, of two parts sand, and one of stone; and, No. 4, two parts stone to one of sand; the lime in these last three cases being the same, viz., one-third the quantity of the sand (as above premised), and properly admixed with water. When sufficiently indurated, a sharpened pole was, by means of a lever, forced down into them with a certain calculable force, and the comparative degree of resistance offered to its entrance, was in reverse order of the numbers. Various other experiments were tried, making alterations in the proportions of the ingredients, but in all cases it was clearly shown that *two parts of stone and one of sand, with sufficient lime dependent on the quality of the materials to make good mortar with the latter*, formed the best concrete.

"In the formation of concrete, solidity is the great end to be attained. We know very well that, although a pit appears to be filled with large stones, the interstices necessarily occurring would still admit a great quantity of smaller stones, and that even then sand to a large amount might be introduced without occupying more space. Variety of size in the stones employed, and consequent need of sand is, therefore, of importance even in this point of view, to say nothing of the necessity for its presence in the formation of mortar, whereby the stones are to be connected. No effect will be produced by the lime alone; it is from its mixture with sand that the properties

of mortar alone result, and as every practical man knows, it is much better that it have too much of this ingredient than too little. . . .

"In the mass No. 4, offering the greatest resistance on our first experiment, the proportions would appear thus: lime, one part; sand, three parts; and stones six parts, by measure, *lime forming one-tenth only of the whole mass;* and this has been proved is quite sufficient, nay, better than more, provided the proportions of sand and stones are maintained. . . .

"It is hardly necessary to observe that if pit gravel be used, it should be well washed in order to free it from all dirt or impurities, and a due quantity of clean sharp river sand, if needed, be added to it, care being taken that the sizes of the stones are as various as possible.

"The methods of mixing and applying concrete are several, each having its advocates and opponents. The one most generally employed, and, as I shall attempt to show, the best, is thoroughly to mix the lime previously ground, with the ballast, in a dry state; sufficient water being then thrown over it to effect a perfect mixture; it should be turned over, at least twice, with shovels,—if oftener so much the better,—put into barrows, and wheeled away for use *instantly*. It is generally found advisable to employ two sets of men to perform this operation, say three in each set; one man to be engaged fetching the water, &c., while the other two turn it over to the second set, and they, repeating the process, turn it over to the barrow men. Sometimes, instead of mixing the materials in a dry state, the ballast is spread out and wetted with water, then covered with the proper proportion of ground lime, and turned over as before.

"After being put into the barrows, it should at once be

wheeled up planks so constructed as to gain a fall of seven yards, and thrown into the foundation, which has the mechanical effect of driving the particles closer together, and giving greater solidity to the whole mass. Soon after being thrown in the mixture is observed to be in commotion, and much heat is evolved, sufficient, indeed, to throw off a large quantity of water in the shape of vapour. This is caused by what is called the slaking of the lime. In combining, condensation is effected—the lime and water together occupying little more space than the lime had before done singly. Now when the particles of matter composing a body are brought closer together, or the interstices (and these occur in all bodies) are filled up with other matter, as by mechanical compression or chemical combination, it is supposed that its capacity for heat is lessened, for caloric is always evolved. . .

"The concrete then being thrown down into the trenches, or intended site of the building, it is customary with some to keep a man constantly employed in levelling and puddling it, as it is termed; this, if it be done, should follow instantly after the barrow load has been emptied; for if the concrete be first allowed to set, much harm will be done by disturbing it; while the benefit that results in any case is but trifling. . For my own part, and it is also the opinion of many practical men, I would not have it in the least disturbed, but allow it to remain precisely in the situation into which it had been thrown from the barrows. As the concrete stratum approaches the surface, this operation may in a degree be necessary in order to obtain a level surface, but whenever it is done, again I would say, let it be done quickly.

"The barrow load of concrete in the fall spreading over the ground will be found, if continued regularly over the

surface, to form a stratum from seven to ten inches thick, which should be allowed to set before throwing in a second; this, however, if the building be of any size has usually taken place at the near end by the time that the far one is completed.

"It is advisable always to perfect one stratum before commencing the second, but if this be impracticable, the second stratum or bed as it approaches the end of the first should stop something short of it, the third in like manner short of the second, and so to the top, forming steps, as it were, upon which the stratum afterwards to be filled in may rest."

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Since the foregoing remarks were written by Mr. Godwin, concrete has been used for a variety of purposes; in sea walls, fence walls, railway sheds, warehouses, and even dwelling houses; and, if any method could be hit upon that should, without altering the character of the material, give it a more pleasing appearance, it would be much more generally used.

But before entering upon the subject of building in concrete, I should wish to point out that Dorking lime is not the only material that can be used in its construction; in the sea wall, at the East Cliff, Brighton, built about sixty-five years since, the component parts of the concrete were hydraulic lime, beach shingle, and sand; and, taking into consideration the severe wear and tear, it must be said to be a successful employment of the material.

In very wet foundations, or where a quick setting concrete is required, blue lias lime has been used with success; but I should not advise its being resorted to unless for the

above reasons, for, although it makes a very hard concrete, it is brittle, and wants the certain amount of elasticity that Dorking lime gives, and causes a tendency to break short upon violent concussion.

There are several patents and methods for building in concrete, but the most popular appears to be that of Mr. Tall,—who has patented an apparatus of a most ingenious kind,—which in a great measure saves the expense of scaffolding.

By Mr. Tall's method the concrete is formed, whilst not, into troughs constructed so that they may be fixed to the thickness of the proposed wall, and scaffolding poles are saved by using iron brackets projecting from the wall.

The proportion that Mr. Tall advises, and has used, is fourteen yards of brick burrs and gravel stone to one yard of Portland cement. He says in his pamphlet—

"The materials for making concrete are found in every part of the United Kingdom, viz., clay, which may be burnt into ballast easily and cheaply, and is a most superior material for concrete; gravel, stone, crushed slag from furnaces, smith's clinkers, oyster shells, broken glass, crockery, or any hard and durable substance. Where sand stone or any flat stone is to be found, walls can be built even cheaper than gravel concrete, as a labourer can break the stone, if too large to go into the machine, taking care to fill up all the space between the large stones with the broken fragments, about six inches deep in the apparatus all round, then pour in grout again, another layer, and so on, until the apparatus is filled up; thus a solid and cheap wall is built.

"The proportions of materials employed in the construction of houses now in progress opposite Perry Street,

Gravesend, with J. Tall's patent apparatus, are as follows:—

	£	s.	d.
Seven yards of burrs from brickfields, at 5s. .	1	15	0
Seven yards of gravel stones, at 3s.	1	1	0
One yard of Portland cement (16 bushels to the cubic yard at 2s.)	1	12	0
Labour, at 2s. per cubic yard	1	10	0
	£5	18	0

"These fifteen yards of concrete will build sixty yards of nine inch work, at a fraction under one shilling and elevenpence (per yard?) If we include the superintendence of a good carpenter, who will do all carpenter's work (no other skilled artisan being required), the yard of nine inch work will not exceed two shillings and sixpence; and in many parts of England, where clay and small coal is at hand, it can be done at two shillings per yard superficial."

I have quoted sufficiently from Mr. Tall's pamphlet to show that if he can prove the figures to be correct, concrete is a very cheap building material; as to its strength and durability there can be no doubt; but, although he says that, "when stuccoed it has a neat and nice appearance," and I do not dissent from its neatness and niceness, it can never, I should imagine, be used for the facing of good work where appearance is studied, and where economy is not the be-all and end-all of the structure.

But, although I cannot advise that the facing of concrete should be merely left and stuccoed, it is such a cheap, and at the same time substantial method of construction, that

there is no reason why, even in first-rate buildings, the backing should not be of this material, and this might be easily worked in Tall's process, the facing being built in to the face of the apparatus, and the filling in afterwards placed. There would be very little that is new-fangled in this, for it would be very nearly reverting to the old Norman, and even Roman, method of building an exterior and interior wall with a space filled in between with a species of concrete; only, in this instance, we should have a better backing.

MEASURES AND THEIR DESCRIPTIONS.

IMPERIAL MEASURE came into operation in Great Britain, on May 1st, 1825, and the principle upon which it is calculated I will describe briefly.

Take a pendulum which will vibrate seconds in London on the level of the sea in a vacuum, divide the part which lies between the axis of suspension and the centre of oscillation into 391·393 equal parts, then one thousand of these parts will be an imperial inch, twelve thousand will be a foot, and thirty-six thousand will be a yard.

The *standard yard* is "that distance between the centres of the two points on the gold studs in the straight brass rod, now in the custody of the clerk of the House of Commons, whereon the words and figures, 'Standard yard, 1760,' are engraved," which is declared to be the genuine standard of the "measure of length called a yard;" and all other measures of length are to be measured from it.

The *standard pound* is determined to be thus measured: take a cube of one inch of distilled water at 62° Fahrenheit; let this be weighed, and let such weight be divided into 252·458 equal parts; then will one thousand of such parts be a troy grain, and 7,000 *grains* are a pound avoirdupois.

For an imperial gallon, ten pounds such as those mentioned above, which gallon will contain two hundred and seventy-seven cubic inches, and two hundred and seventy-four one-thousandth parts of a cubic inch.

TABLE OF SEVERAL STANDARD MEASURES.

LONG MEASURE.

Barleycorns.		Inches.		Feet.		Yards.		Poles.		Furlongs.		Mile.
3	=	1										
36	=	12	=	1								
108	=	36	=	3	=	1						
594	=	198	=	16½	=	5½	=	1				
23,760	=	7,920	=	660	=	220	=	40	=	1		
190,080	=	63,360	=	5,280	=	1,760	=	320	=	8	=	1

ALSO,

4 inches	=	1 hand.
6 feet	=	1 fathom.
3 miles	=	1 league.
60 geographical miles	=	1 degree.
69½ English miles	=	1 degree, nearly.

360 degrees, or 25,000 miles, is equal to the circumference of the earth, nearly.

CLOTH MEASURE.

Inches.		Nails.		Quarters.		
2¼	=	1				
9	=	4	=	1		
36	=	16	=	4	=	1 yard.
27	=	12	=	3	=	1 ell Flemish.
45	=	20	=	5	=	1 ell English.
54	=	24	=	6	=	1 ell French.

SQUARE MEASURE.

Inches.		Feet.		Yard.		Pole.		
144	=	1						
1,296	=	9	=	1				
39,204	=	272¼	=	30¼	=	1		
1,568,160	=	10,890	=	1,210	=	40	=	1 rood.
6,272,640	=	43,560	=	4,840	=	160	=	1 acre.

Also 5½ yards = 1 pole.
40 poles = 1 rood.
4 roods = 1 acre.

Superficial, *Square*, or *Land measures* are calculated from the yard of 36 inches multiplied into itself; thus, 1,296 square inches = 1 square yard; also, the length of a pole being 5½ yards, the square pole contains 30¼ square yards. A square mile contains 640 square acres. In measuring fens and woodlands 18 feet are generally allowed to a pole, and 21 feet in forest land. The ancient measure called a *hide* contained about one hundred arable acres, and five hides were a knight's fee. At the time of the Norman conquest there were two hundred and forty-three thousand and sixty-three hides in England.

LAND TABLE.

		Side of square.				Diameter of a circle.			
	Square yds.	yds.	ft.	in.	pts.	yds.	ft.	in.	pts.
1 acre	4840	69	1	8	6	78	1	6	1
3 roods	3630	60	0	9	0	67	2	11	5
2 roods	2420	47	0	7	0	51	1	0	4
1 rood	1210	34	2	4	3	39	0	0	0

AVOIRDUPOIS WEIGHT.

16 drams	= 1 ounce.
16 ounces	= 1 pound.
28 pounds	= 1 quarter.
4 quarters	= 1 hundredweight.
20 hundredweight	= 1 ton.

TROY WEIGHT.

		marked
24 grains	= 1 pennyweight.	dwt.
20 pennyweights	= 1 ounce.	oz.
12 ounces	= 1 pound.	lb.

APOTHECARIES' WEIGHT.

20 grains	= 1 scruple.	scr.
3 scruples	= 1 dram.	dr.
8 drams	= 1 ounce.	oz.
12 ounces	= 1 pound.	lb.

FRENCH DECIMAL LONG MEASURE.

Millimetre	=	·03937	English inches.
Centimetre	=	·39371	"
Decimetre	=	3·93710	"
Metre	=	39·37100	"
Myriametre	=	6·2138	English miles.
Kilometre	=	1093·6000	yards.

An inch is ·0254 metre. 2441 inches = 62 metres.
1000 feet nearly 305 metres.

FRENCH SQUARE MEASURE.

1 metre	=	1·196033	English yards.
1 are	=	0·098845	roods.
1 hectare	=	2·473614	acres.

FRENCH DECIMAL WEIGHTS.

Gramme	=	15·436	grains.
Decigramme	=	1·5434	"
Centigramme	=	0·1543	"
Milligramme	=	0·0154	"
Decagramme	=	154·3400	"
Hectogramme	=	3·2154	oz. troy.
" or	=	3·5270	" avoirdupois.
Kilogramme	=	2·6795	lbs. troy.
" or	=	2·2048	" avoirdupois.
Myriagramme	=	28·7850	lbs. troy.
" or	=	22·0480	" avoirdupois.
Quintal	=	1 cwt., 3 qrs, 24½ lbs.	
Millier or Bar	=	9 tons, 10 cwt., 3 qrs., 12 lbs.	

VALUATION OF ESTATES.

Memoranda of Facts in matters of Valuation and Calculation.

	PER CENT.
The value of Freehold land is generally considered at 30 to 33 years' purchase . . .	3
Freehold ground rent 25 to 30 years' purchase .	4
Freehold houses and buildings, 1st and 2nd class, 18 to 20 years' purchase . . .	5
Ditto, 3rd and 4th class, 16 years' purchase .	6
Leasehold property, 1st and 2nd class houses and buildings, 15 to 16 years' purchase . .	6
Also the unexpired term of years for long terms must be calculated.	
Leasehold property, 2nd and 3rd class, 14 to 15 years' purchase	7
Ditto, 3rd and 4th class, 12 to 13 years' purchase .	8
Ditto, 4th and 5th class, 11 to 12 years' purchase .	9
Ditto, 5th and 6th class, 10 years' purchase .	10

Renewing Leaseholds under Deans and Chapters.

The Dean and Chapter of Westminster renew their leases, originally granted for 40 years, under the 8 per cent.

tables, the renewing fine of one year's rent payable by the tenant every fourteen years, except for very superior houses at the West end of the town, which are renewed under the 7 per cent. tables, the renewing fine of 1½ years being payable by the tenant every fourteen years.

On the Bishop of Winchester's Estates.

1½ year's renewing fines for 14 years lapsed in a lease originally granted for 40 years, 7 per cent. tables, if next the river; or 1¼ year's fine inland, 8 per cent.

City of London Leases, Scale of Ground Rents.

			s.	d.		d.
1st	class situation,	per ft. frontage	5	0	per ft. deep	3
2nd	ditto	ditto	4	0	ditto	2
3rd	ditto	ditto	3	0	ditto	1½
4th	ditto	ditto	2	0	ditto	1
5th	ditto	ditto	1	0	ditto	0½

Renewing fine, 7 years' ground rent every 14 years for a term of 41 or 61 years,

Lessee to insure repairs, &c.

Purchase of Good-will in Retail Trade, &c.

If retail trade is carried on, giving credit, say 1 year's purchase.

If retail trade is a ready money concern, say 1½ year's purchase.

If retail trade is subject to be annihilated, as a public-house, say 2 to 3 years' purchase.

Calculating rent for fixtures, say 12½ per cent. or ⅛, being 2s. 6d. in the pound.

Allowance to Tenants for Repairs.

8 per cent. allowed for amount of repairs		for	21	years.
7	ditto	ditto	31	„

Or generally say:

12 per cent. allowed for amount of repairs		for	12	„
10	ditto	ditto	15	„
9	ditto	ditto	18	„
8	ditto	ditto	23	„
7	ditto	ditto	33	„
6	ditto	ditto above	33	„

Purchase of Land Tax.

To be made under the Land Tax Act, at the price of the 3 per cent. Consols, and to which add one-tenth to the amount, the income tax being now taken off.

Memoranda relative to the Valuation of Leases.

d.		£	s.	d.	
0¼	per foot . .	45	7	6	per acre.
0½	„ . .	90	15	0	„
0¾	„ . .	136	2	6	„
1	„ . .	181	10	0	„
1¼	„ . .	226	17	6	„
1½	„ . .	272	5	0	„

Crown Lands.

The mode adopted in respect to the valuation for renewal of the crown leases. Allowance for repairs as under:

Houses £25 per annum and under,		10	per cent.
"	£25 to £50 "	6	"
"	£50 to £100 "	7	"
"	£100 and upwards	5	"

The rack rent not an overstrained rent on account of Crown property, and to encourage improvements, viz.:

	£	s.	d.	£	s.	d.
Rack rent per annum . . .				£63	0	0
Deductions:						
Present repairs, £200	14	0	0			
Ordinary repairs .	3	3	0			
Land tax . .	3	3	0			
Insurance, £700 .	0	15	0			
Outgoings . .	4	8	0			
				25	9	0
				£37	11	0

Say £40 per annum, clear rental.

Or another case:

	£	s.	d.	£	s.	d.
Rack rent, per annum . .				£150	0	0
Deductions:						
Present repairs, £250	17	10	0			
Ordinary repairs .	7	10	0			
Land tax . .	5	12	0			
Insurance . .	2	10	0			
Contingencies .	7	10	0			
				40	12	0
				£109	8	0

With Crown leases the custom under Act of Parliament is to renew when within 20 years of being expired, not

earlier; a new rent is then assessed, taking one-third fine and two-thirds rent, in order to secure more effectually the rent so reserved.

Increase of Population.

First 10 years of the century:

			PER CENT.
Increase in England and Wales,		1800 to 1810	15½
Ditto	ditto	1810 to 1820	17½
Ditto	ditto	1820 to 1830	15½
Population in England and Wales,		1801	9 millions.
Ditto	ditto	1810	10 "
Ditto	ditto	1821	12 "
Ditto	ditto	1851	17,927,609
Ditto	ditto	1861	20,066,224
Ditto	ditto	1871	22,704,108

Out of 1000 persons there die annually about 30, and the number of the inhabitants of every city and county is renewed every 30 years or nearly so.

Calculations have been made tending to show that the proportion of mortality is diminishing, which fact is confirmed by the returns in several great cities, proving incontestably the material amelioration in our physical condition for a higher state of civilisation.

100 years since	1	died in	30
50	"	1	"	40
30	"	1	"	48
20	"	1	"	52
Present time		1	"	60

Charges for Surveys and Valuations.

In the improvements made in London, Regent Street, Strand, Westminster, the City, and St. Katherine's Docks, the charges made have been at the rate of ½ per cent., and three guineas for each surveyor attending to give evidence before a Judge and Jury. It is usual to charge 1 per cent. for the first thousand pounds, and the remainder ½ per cent.

Her Majesty's Commissioners for building churches allow, for travelling expenses, 1s. 6d. per mile out, and the same back, but no expenses, and four journeys, not more, allowed to each church.

Table showing the number of years' purchase upon the net rental required to return a given rate of interest.

Rate of Interest per cent. per annum.	Number of years' purchase on the net rental.
2	50
2¼	44·4
2½	40
2¾	36·3
3	33·3
3¼	30·7
3½	28·5
3¾	26·6
4	25
4¼	23·25
4½	22·2
4¾	21
5	20
5¼	19
5½	18·1
5¾	17·4
6	16·6
6¼	16
6½	15·4
6¾	14·8
7	14·2
7¼	13·7
7½	13·3
7¾	12·9
8	12·5

Example 1. An estate required to pay 4½ per cent. interest must be purchased at 22·2 years rental.

Example 2. An estate purchased at 30·7 years' purchase pays 3¼ per cent. interest.

STAMPS.

Agreements under Hand.

	£	s.	d.
For £5 and upwards . . .	0	0	6

Agreement for Lease or Tack.

	£	s.	d.
1. For any definite term less than a year :—			
(*a.*) Of any dwelling house or part, &c. rent not exceeding £10 per ann. . .	0	0	1
(*b.*) For any furnished dwelling house or part, rent exceeding £25 per ann.	0	2	6
(*c.*) Of any lands, tenements of heritable subjects, except as aforesaid .	The same duty as lease for a year, at the rent reserved for a definite term.		

2. For any other definite term, or for any indefinite :—
Of any lands, &c., when the consideration, in any part, consists of money, stock, or security :

In respect of such consideration, the same duty as the conveyance on a sale for the same consideration.

Where the consideration or any part of the consideration is any rent :

In respect of such consideration, if the rent, whether received as a yearly rent or otherwise, is at a rate or average rent.

	If the term is definite, and does not exceed 35 years, or is indefinite.			If the term being definite exceeds 35 years, but does not exceed 100 yrs.			If the term being definite exceeds 100 years.		
	£	s.	d.	£	s.	d.	£	s.	d.
Not excdg. £5 per ann.	0	0	6	0	3	0	0	6	0
Exceeding — Not exceeding.									
£5 . £10	0	1	0	0	6	0	0	12	0
10 . 15	0	1	6	0	9	0	0	18	0
15 . 20	0	2	0	0	12	0	1	4	0
20 . 25	0	2	6	0	15	0	1	10	0
25 . 50	0	5	0	1	10	0	3	0	0
50 . 75	0	7	6	2	5	0	4	10	0
75 . 100	0	10	0	3	0	0	6	0	0
For every full sum of £50 and also for any fractional part of £50 above £100 . .	0	5	0	1	10	0	3	0	0

3. Of any other kind whatsoever not hereinbefore described . . . 0 10 0

Appraisements.

Appraisements or valuations of any property, or of any interest therein, the annual value, dilapidations, repairs, materials, and labour used or to be used.

			£	s.	d.
When the amount of the appraisement or valuation does not exceed £5 . .			0	0	3
Exceeds	£5 and does not exceed	£10 .	0	0	6
"	10 " "	20 .	0	1	0
"	20 " "	30 .	0	1	6
"	30 " "	40 .	0	2	0
"	40 " "	50 .	0	2	6
"	50 " "	100 .	0	5	0
"	100 " "	200 .	0	10	0
"	200 " "	500 .	0	15	0
"	500 . .	. .	1	0	0

EXEMPTIONS.

1. Appraisements or valuations made for, and for the information of one party only, and not obligatory by assessment or operation of law.

2. Appraisement or valuation made in pursuance of the order of any Court of Admiralty, Vice Admiralty, or any Court of Appeal from any sentence, adjudication, or judgment of any Court of Admiralty, or Vice-Admiralty.

3. Appraisement or valuation of any property made for the purpose of ascertaining the legacy or succession duty.

Every appraiser shall, within fourteen days after making his valuation, write out the same in full words and figures, upon duly stamped material, and if he neglects to do so, shall forfeit the sum of fifty pounds.

Any person who receives from an appraiser, an appraisement or valuation, or pays for the making out of the same, unless the same be written out and stamped, shall forfeit the sum of twenty pounds.

Schedule Inventory.

Schedule Inventory, or document of any kind whatsoever referred to, in, or by, and intended to be used or given in evidence as part of, or as material to, any other instrument charged with any duty, but which is separate and distinct from, and not endorsed or annexed to such other instrument:

When such other instrument is chargeable with any duty not exceeding 10s., the same duty as such other instrument.

In any other case, 10s.

EXEMPTIONS.

1. Printed proposals of any insurance company.

2. Any public map, plan, survey, apportionment, allotment, award, and other parochial or public document or writing made pursuant to any act of parliament, and deposited or kept for reference in any registry, or in any public office, or with the public books, papers, or writings of any parish.

Bills of Exchange.

	£	s.	d.
Payable on demand . . .	0	0	1
BILL OF EXCHANGE of any other kind whatever (except a bank note), and PROMISSORY NOTE, of any kind whatsover (except a bank note), drawn, or expressed to be payable, or actually paid, or endorsed, or in any manner negotiated in the United Kingdom: When the amount of money for which the bill or note is drawn or made does not exceed £5 . . .	0	0	1
Exceeds £5 and does not exceed £10 .	0	0	2
" 10 " " 25 .	0	0	3
" 25 " " 50 .	0	0	6
" 50 " " 75 .	0	0	9
" 75 " " 100 .	0	1	0
" 100 for every £100, and also for any fractional part of £100 of such amount or value	0	1	0

INTEREST TABLE.

TABLE showing amount of Interest for 7 days upon amounts from £1 to £100.

Amnts.	3 per cent.		3½ per cent.		4 per cent.		4½ per cent.		5 per cent.	
£	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.
1	0	0	0	0	0	0	0	0	0	0
2	0	0¼	0	0¼	0	0¼	0	0¼	0	0¼
3	0	0¼	0	0¼	0	0½	0	0½	0	0½
4	0	0½	0	0½	0	0½	0	0¾	0	0¾
5	0	0½	0	0¾	0	0¾	0	1	0	1
6	0	0¾	0	0¾	0	1	0	1	0	1¼
7	0	0¾	0	1	0	1¼	0	1¼	0	1½
8	0	1	0	1	0	1¼	0	1½	0	1¾
9	0	1	0	1¼	0	1½	0	1¾	0	2
10	0	1¼	0	1½	0	1¾	0	2	0	2¼
20	3	2¾	0	3¼	0	3½	0	4	0	4½
30	0	4	0	5¼	0	5½	0	6	0	6¾
40	0	5½	0	7	0	7¼	0	8¼	0	9
50	0	6¾	0	7¾	0	9	0	10¼	0	11½
100	1	1¾	1	6	1	6¼	1	8¼	1	11

Directions for finding interest by the above table at other rates than those for which they are calculated :—

For 2 per cent. take half of the interest at 4 per cent.
For 2½ per cent. take half of the interest at 5 per cent.
For 6 per cent. double 3 per cent.
For 7 per cent. take 4 per cent. and 3 per cent.
For 8 per cent. double 4 per cent.
For 9 per cent. take 5 per cent. and 4 per cent.
For 10 per cent. double 5 per cent.

GOVERNMENT TABLE.

Showing the Annual Premium which must be paid by the assured person from any year from 16 to 60 years, in order to assure £100 on his or her death.

Age next Birthday.	Annual Premium. £	s.	d.	Age next Birthday.	Annual Premium. £	s.	d.
17	1	13	6	38	2	18	10
18	1	14	5	39	3	0	9
19	1	15	4	40	3	2	9
20	1	16	2	41	3	4	10
21	1	17	1	42	3	7	1
22	1	18	0	43	3	9	5
23	1	18	11	44	3	11	10
24	1	19	10	45	3	14	5
25	2	0	10	46	3	17	2
26	2	1	11	47	4	0	1
27	2	3	0	48	4	3	2
28	2	4	1	49	4	6	4
29	2	5	4	50	4	9	10
30	2	6	7	51	4	13	5
31	2	7	10	52	4	17	3
32	2	9	3	53	5	1	3
33	2	10	8	54	5	5	6
34	2	12	2	55	5	10	0
35	2	13	8	56	5	14	10
36	2	15	4	57	6	0	0
37	2	17	1	58	6	5	6
				59	6	11	5
				60	6	17	8

GOVERNMENT TABLE.

Showing what sum payable on death may be assured by the payment of an annual premium of one pound from 16 to 60 years of age.

Age next Birthday.	Sums Insured.			Age next Birthday.	Sums Insured.		
	£	s.	d.		£	s.	d.
17	59	15	6	39	30	16	9
18	58	3	5	40	29	16	5
19	56	13	5	41	28	16	5
20	55	5	7	42	27	16	9
21	53	19	9	43	26	17	4
22	52	14	3	44	25	18	4
23	51	9	1	45	24	19	8
24	50	4	2	46	24	1	3
25	48	19	6	47	23	3	3
26	47	15	1	48	22	5	7
27	46	10	11	49	21	8	2
28	45	6	11	50	20	11	6
29	44	3	2	51	19	15	2
30	42	19	7	52	18	19	3
31	41	16	3	53	18	3	7
32	40	13	2	54	17	8	4
33	39	10	3	55	16	13	4
34	38	7	8	56	15	18	9
35	37	5	3	57	13	4	6
36	36	3	1	58	14	10	7
37	35	1	3	59			
38	33	19	8	60			

VARIORA.

APOSTOLIC SYMBOLS.

St. Matthew	is represented	by an	Angel.
St. Mark	,,	,,	Lion.
St. Luke	,,	,,	Ox.
St. John	,,	,,	Eagle.

CHURCH SEATS.

	ft.	in.
Width from back to back - -	3	2
Height of standard - - -	3	2
Width of standard (or end) - -	1	6
Width of seat - - -	1	2
Height of seat - - -	1	5
Height of back - - -	2	10

WINE BINS

Should be 2 feet 6 inches wide, 2 feet long (the height to be regulated by the height of the vault). This will take a

row of bottles eight long and two deep, placed neck and neck. The first shelf should be about 3 feet from the ground. Twenty-five dozen make a hogshead.

CONSTRUCTION OF TRACERIED WINDOWS.

All the joints of the tracery, mullions, and sills to be properly dowelled with Portland cement, run into groves cut for the purpose.

COPINGS.

Every joint to have two hard stone or slate dowels fixed with cement, and also a groove, nearly the full width of coping, cut in, which is also to be run with Portland cement, the foot, apex, and bond stones to be out of the solid.

GABLE CROSSES

To be fixed with copper dowel, 6 inches by 1 inch, by ½ inch, into top stone.

HEATING.

One foot super. of pipe heated to 200 degrees, will cause an average of 58 degrees of heat in 150 cubic feet of air.

STAINED GLASS.

Average price, with figures and shines, £2 per ft. super.

INDURATION.

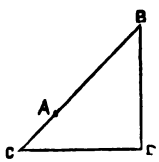
The monuments of Westminster were indurated with gum shellac dissolved in spirits of wine.

SIDES OF POLYGONS.

To find the length of a side, the diameter being given :

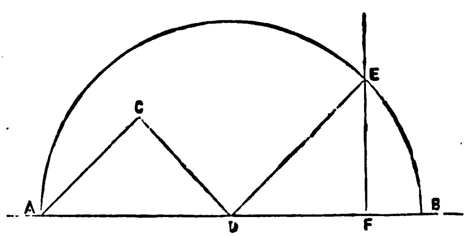
For a Hexagon, multiply diameter by		.	·577
Octagon	„ „	.	·414
Decagon	„ „	.	·325
Dodecagon	„ „	.	·268

The diameter being given to find the side of an octagon :



Draw the horizontal line C D, and the perpendicular line D B, equal to C D ; draw the diagonal line C B, and make B A equal to C D. C A will be the required side.

The side of an octagon being given, to find the diameter.



Draw the horizontal line A B; from the point A draw the line A C, the length of the given side, at an angle of 45 degrees with A B; at right angles with A C draw the line C D (also being the length of the given side) from

the point D; at the distance D A describe the circle A E B, from the point D draw the straight line D E parallel with A C, cutting the circle at E; from the point E drop the perpendicular line E F. Then A F is the diameter required.

WATER.

1 cubic foot of water weighs 62·5 lbs.
1 gallon about . 10· lbs.
277·25 cubic inches = 1 gallon.

To find the quantity of water (in gallons) in a given cylinder, multiply the square of the diameter by the height, and divide by ·353.

BELLS.

The following account, copied from a recent one delivered by one of our most celebrated bell founders, will give data from which an estimate for church bells may be made.

	£	s.	d.
Bell weighing 10 cwt. 0 qr. 7 lbs., at £6 10s. 8d. per cwt.	65	14	10
Clapper	1	0	0
Stock, wheel, ironwork, and trusses . . .	6	10	0
Man's time, &c., making frame for four bells, and hanging bells complete . . .	15	10	0
	£88	14	10

To which add cost of carriage.

MONUMENTS.

Date.				Height.	Diameter.
A.D.	118.	Trajan, Rome.	Doric.	115 ft.	12 ft.
„	162.	Antonine, Rome.	„	123 ft.	13 ft.
„	1671.	Monument, London.	„	202 ft.	15 ft.
„	1806.	Napoleon, Paris.	„	115 ft.	12 ft.
„	1832.	Duke of York, London.	„	109 ft.	11 ft.
„	1839.	Nelson, London.	Corinthian.	145½ ft.	10½ ft.

TO MEASURE FALLEN TIMBER.

Gird a string round the middle of the tree, and fold it twice, which will give the fourth part of the girth, and may be considered the true side of the square. Then measure from the butt up to so high as the timber will hold 6 inches, quarter girth.

THE MILLIARE, OR ROMAN MILE,

Consisted of 1,000 paces of 5 feet each, and was, therefore 5,000 feet. The Roman foot was 11·6496 English inches. The Roman mile would be 1,618 English yards, 142 yards less than the English statute mile.

TO REDUCE FRENCH MEASURES INTO ENGLISH, AND VICE VERSA.

Centimetres to inches, divide by	.	2·5600
Metres to feet „	.	0·3048
Kilometres to miles „	.	1·6093
Square metres to square feet „	.	0·9293
Cube metres to cube feet „	.	0·028314

To reduce English measures to French, divide instead of multiply.

TO CALCULATE THE PRICE OF A ROD OF BRICKWORK.

The price will depend upon the quality of the bricks, and the kind of workmanship. In building foundations and party walls, which are commonly done with place bricks, 1,500 may easily be laid in one day. In garden walls, barns, and common or second class houses, about 1,000 may be laid in one day; and in gray stock, marl, or other fronts where great care is required, the quantity laid may not exceed 500 per day. The expense per rod will also depend upon the wages, the skill of the craftsmen, the situation, whether lodging money is paid, and many other causes. The following example, however, is given, as a datum from which the price may be calculated, altering the prices as circumstances and experience may require, and is calculated from the work in a well built house.

	£	s.	d.
To 4,500 stock bricks, p. c. 38s. per 1,000 .	8	11	0
1½ cwt. of lime, at 12s. per cwt. . .	1	1	0
2 loads of sand at 4s. per load. . .	0	8	0
¾ day, labourer, to slaking lime, &c., and mixing mortar, 3s. 6d. per day .	0	2	7½
Bricklayer, 5 days, 6s. per day . .	1	10	0
Labourer, 5 days, 3s. 6d. per day . .	0	17	6
	12	10	1½
Add 1½ per cent. for scaffolding, &c. . .	0	3	9
„ 15 „ for profit on prime cost .	1	17	6
	£14	11	4½

ROOF COVERINGS, AND THEIR RELATIVE WEIGHTS.

Plain tiles . .	8 cwt. per sq. (of 100 ft.)		
Pan tiles . .	9½	"	"
Slating . . .	7	"	"
Lead, at 7 lbs. per foot super.	6¼	"	"
Corrugated iron . .	2	"	"
Copper or zinc, 16 oz. per ft. super.	1	"	"

PORTLAND STONE.

The following comparisons will show the relative peculiarities of good and bad Portland stone, considering the specimens, when examined, subject in every respect to the same conditions, such as being equally wet or dry, &c.

GOOD.	BAD.
Preponderance of weight.	Deficiency of weight.
Dark coloured.	Light coloured.
Uniform colour.	Party coloured.
Compact and crystalline.	Open and powdery.
Hard to crush.	Friable.

From C. H. Smith on *Stone Used for Building.*

To find the areas of Polygons, the length of one side being given.

Trigon,	figure of 3 sides	0·4350	Multiply the square of the side by the figures in this column.
Pentagon,	" 5 "	1·7203	
Hexagon,	" 6 "	2·5981	
Heptagon,	" 7 "	3·6339	
Octagon,	" 8 "	4·8244	
Nonagon,	" 9 "	6·1818	
Decagon,	" 10 "	7·6942	
Undecagon,	" 11 "	9·3556	
Duodecagon,	12 "	11·1962	

MICE IN PARTITIONS AND SKIRTINGS.

The spaces in partitions and behind skirtings are often thoroughfares for mice, which also contrive to travel from floor to floor. Plaster or wood stopping is not so efficacious as the use of broken glass in the passages or runs that they make.

TO MEASURE THE CONTENTS OF CYLINDERS.

Square the diameter in inches, cut off one figure to the right, the remainder gives the number of gallons in 3 feet.

EXAMPLE: $10 \times 10 = 10{,}0$, or 10 gallons in 3 feet.
$7 \times 7 = 4{,}9$, or 4 " "

TABLE OF CIRCUMFERENCES, AREAS, &c., OF CIRCLES.

Diameter.	Circumference.	Area.	Side of equal square.
in.	in.	in.	in.
6	18·84	28·27	5·31
9	28·27	63·61	7·97
12	37·69	113·09	10·63
15	47·12	176·71	13·29
18	56·54	254·46	15·95
21	65·79	346·36	19·61
24	75·39	452·39	21·26
27	84·82	572·55	23·92
30	94·24	706·86	26·58
33	103·67	855·30	29·24
36	113·09	1017·87	31·90
39	122·52	1194·59	34·56
42	131·94	1385·44	37·20
45	141·37	1590·43	39·87
48	150·79	1809·56	42·53
51	160·22	2042·82	45·19
54	169·64	2290·22	47·85
57	179·07	2551·76	50·50
60	188·49	2827·44	53·17
63	197·92	3117·25	55·83
66	207·34	3421·20	58·48
69	216·77	3739·28	61·14
72	226·19	4071·51	63·80
75	235·62	4417·87	66·46
78	245·04	4778·37	69·12
81	254·46	5153·00	71·78
84	263·89	5541·78	74·44
87	273·31	5944·69	77·09
90	282·74	6361·74	79·75
93	292·16	6792·92	82·41
ft. in.	ft. in.	ft.	ft. in.
8 0	25 $1\frac{1}{2}$	50·26	7 $0\frac{1}{8}$
8 3	25 11	52·41	7 $1\frac{3}{4}$
8 6	26 $8\frac{3}{8}$	56·74	7 $6\frac{3}{8}$
8 9	27 $5\frac{3}{4}$	60·13	7 $9\frac{1}{8}$
9 0	28 $3\frac{1}{2}$	61·19	8 $3\frac{1}{8}$
9 3	29 $1\frac{1}{2}$	63·92	8 $8\frac{1}{2}$
9 6	32 $2\frac{3}{8}$	82ft. 5in.	9 1
9 9	32 $11\frac{3}{4}$	86 5	9 $3\frac{5}{8}$

Diameter.		Circumference.		Area.		Side of equal square.	
ft.	in.	ft.	in.	ft.	in.	ft.	in.
10	0	33	9¼	90	7	9	6¼
10	3	34	6⅝	95	0	9	8⅞
10	6	35	4⅛	99	4	9	11⅝
10	9	36	1½	103	8	10	2¼
11	0	36	10⅞	108	4	10	5
11	3	37	8⅜	113	0	10	7⅝
11	6	38	5¾	117	8	10	10¼
11	9	39	3¼	122	7	11	0⅞
12	0	40	0⅝	127	6	11	3⅝
12	3	40	10	132	7	11	6¼
12	6	41	7½	137	8	11	8⅞
12	9	42	4⅞	143	1	11	11½
13	0	43	2¼	148	4	12	2⅞
13	3	43	11¾	153	9	12	5½
13	6	44	9⅛	159	4	12	7⅞
13	9	45	6⅝	165	1	12	10½
14	0	46	4	170	8	13	1⅛
14	3	47	1½	176	7	13	3¾
14	6	47	10⅞	182	6	13	6⅜
14	9	48	8⅜	188	6	13	8⅞
15	0	49	5¾	194	8	13	11½
15	3	50	3⅛	201	0	14	2⅛
15	6	51	0½	207	3	14	4¾
15	9	51	10	213	8	14	7⅜
16	0	52	7⅜	220	3	14	10
16	3	53	4⅞	226	9	15	0⅝
16	6	54	2⅜	233	7	15	3½
16	9	54	11¾	240	5	15	6⅞
17	0	55	9⅛	247	4	15	8¾
17	3	56	6½	254	4	15	11⅜
17	6	57	4	261	5	16	2⅛
17	9	58	1⅜	268	8	16	4¾
18	0	58	10⅞	276	1	16	7⅜
18	3	59	8¼	283	5	16	10
18	6	60	5¾	291	0	17	0¾
18	9	61	3⅛	298	6	17	3⅜
19	0	62	0⅝	306	3	17	6
20	0	62	10	314	1	17	8⅝

TABLE OF NUMBERS

Squared and Cubed, and their Squared Roots.

No.	Square.	Cube.	Square Root.	No.	Square.	Cube.	Square Root.
1	1	1	1·000	39	1521	59319	6·244
2	4	8	1·414	40	1600	64000	6·324
3	9	27	1·732	41	1681	68921	6·403
4	16	64	2·000	42	1764	74088	6·480
5	25	125	2·236	43	1849	79507	6·557
6	36	216	2·449	44	1936	85184	6·633
7	49	343	2·645	45	2025	91125	6·708
8	64	512	2·828	46	2116	97366	6·782
9	81	729	3·000	47	2209	103823	6·855
10	100	1000	3·162	48	2304	110592	6·928
11	121	1331	3·316	49	2401	117649	7·000
12	144	1728	3·464	50	2500	125000	7·071
13	169	2197	3·605	51	2601	132651	7·141
14	196	2744	3·741	52	2704	140608	7·211
15	225	3375	3·872	53	2809	148877	7·280
16	256	4096	4·000	54	2916	157464	7·348
17	289	4913	4·123	55	3025	166375	7·416
18	324	5832	4·242	56	3136	175616	7·483
19	361	6859	4·358	57	3249	185193	7·549
20	400	8000	4·472	58	3364	195112	7·615
21	441	9261	4·582	59	3481	205379	7·681
22	484	10648	4·690	60	3600	216000	7·745
23	529	12167	4·799	61	3721	226981	7·810
24	576	13824	4·898	62	3844	238328	7·874
25	625	15605	5·000	63	3969	250047	7·937
26	676	17576	5·099	64	4096	262144	8·000
27	729	19683	5·196	65	4225	274925	8·062
28	784	21952	5·291	66	4356	287496	8·124
29	841	24389	5·385	67	4489	300763	8·185
30	900	27000	5·477	68	4624	314432	8·246
31	961	29791	5·567	69	4761	328509	8·306
32	1024	32768	5·656	70	4900	343000	8·366
33	1089	35937	5·744	71	5041	357911	8·426
34	1156	39304	5·830	72	5184	373248	8·485
35	1225	42875	5·916	73	5329	389017	8·544
36	1296	46656	6·000	74	5476	405224	8·602
37	1369	50653	6·082	75	5625	421875	8·660
38	1444	54872	6·164	76	5776	438976	8·717

No.	Square.	Cube.	Square Root.	No.	Square.	Cube.	Square Root.
77	5929	456533	8·774	114	12996	1481544	10·677
78	6084	474552	8·831	115	13225	1520875	10·723
79	6241	493039	8·888	116	13456	1560896	10·770
80	6400	512000	8·944	117	13689	1601613	10·816
81	6561	531441	9·000	118	13924	1643032	10·862
82	6724	551368	9·055	119	14161	1685159	10·908
83	6889	571787	9·110	120	14400	1728000	10·954
84	7056	592704	9·165	121	14641	1771561	11·000
85	7225	614125	9·219	122	14884	1815848	11·045
86	7396	636056	9·273	123	15129	1860867	11·090
87	7569	658403	9·327	124	15376	1906624	11·135
88	7744	681572	9·380	125	15625	1953125	11·180
89	7921	704969	9·433	126	15876	2000376	11·229
90	8100	729000	9·486	127	16129	2048383	11·269
91	8281	753571	9·539	128	16384	2097152	11·313
92	8464	778668	9·591	129	16641	2146689	11·357
93	8649	804357	9·643	130	16900	2197000	11·408
94	8836	830584	9·695	131	17161	2248091	11·445
95	9025	857375	9·746	132	17424	2299968	11·489
96	9216	884736	9·797	133	17689	2352637	11·532
97	9409	912673	9·848	134	17956	2406104	11·575
98	9604	941192	9·899	135	18225	2460375	11·618
99	9801	970299	9·949	136	18496	2515456	11·661
100	10000	1000000	10·000	137	18769	2571353	11·704
101	10201	1030301	10·049	138	19044	2628072	11·747
102	10404	1061208	10·090	139	19321	2685619	11·789
103	10609	1092727	10·148	140	19600	2744000	11·832
104	10816	1124864	10·198	141	19881	2803221	11·874
105	11025	1157625	10·246	142	21064	2863288	11·916
106	11236	1191016	10·295	143	20449	2924207	11·951
107	11449	1225043	10·344	144	20736	2985984	12·000
108	11664	1259712	10·392	145	21025	3048625	12·041
109	11881	1295029	10·400	146	21316	3112136	12·083
110	12100	1331000	10·488	147	21609	3176523	12·124
111	12321	1367631	10·535	148	21904	3241792	12·165
112	12544	1404928	10·583	149	22201	3307949	12·206
113	12769	1442897	10·630	150	22500	3375000	12·247

DILAPIDATIONS

INTRICATE and difficult as the laws of dilapidations appear to be generally, those concerning church property, from their stringency, appear to be the most so. It would appear that all "grades of church officers" are liable not only to repairs, but to preservation from decay; and if necessary, to the rebuilding and restoration, even in case of tempest, fire, or decay by time; the only exception is the curate, from his uncertainty of tenure; but even he, where the whole profit of a benefice has been allotted to him, must submit to the rector or vicar, &c., holding back for the repair of the chancel and parsonage as much as one-fourth of the profits, if so much have been expended during the year.*

With regard to other property, it appears that tenants are not to be generally held liable for damage arising from fair wear and tear, the action of the elements, or the results of the lapse of time; and the more frail the tenure, the less liable is the tenant; hence, against a tenant-at-will a landlord can have no remedy for repairs, though such tenant is liable for trespass if he commit wilful damage. Tenants for a longer term are not only liable for dilapidations arising from "avoidable accident, carelessness, or wilful damage," but under covenants or agreements are liable for damages arising from neglect. The tenant from year to year is not only liable for damage from avoidable accident, &c., but for all dilapidations which are not the result of occupation, or of inevitable accident; thus, if windows or doors be torn off their hinges, glazing broken or cracked, chimney-pieces broken, water-closets stopped up, papering torn down,—such dilapidations not being the necessary consequences of fair wear and tear, the tenant by the year is liable to damages for the same; but he is not liable for any decay, breakage from decay, or loosening, unfastening, or falling off by lapse of time; neither is he liable for accidents from the elements; but a yearly tenant is bound to keep the premises wind and water tight, more particularly where a trifling expense will effect this; unless, indeed, from the effects of time, any parts of the building are rapidly falling to pieces.

With regard to liability for dilapidations of the "tenant to repair under covenant," more particularly a general covenant to repair, the law is so strict and rigid, that a lessee cannot be too careful nor too cautious with regard to his covenant with the lessor; for under such a general covenant to repair, however great may be the dilapidations, even to the destruction by fire or otherwise, from any cause whatsoever, however unexpected or unforeseen, the law will enforce from the lessee a total restoration of the premises, and the same with regard to a so covenanting lessor; but the courts will construe such restorations to be in a reasonable manner; hence, if a lessor covenants to repair, the law will compel him to rebuild in a case of destruction by fire or other accident; but if the lessor hath not so covenanted, he is not held liable so to rebuild or restore, though he maintains his right to sue for rent. A lessee also continues liable for rent, under a covenant to repair, "casualties by fire and tempest excepted," though the landlord refuse to rebuild or repair in such case because he is not bound by covenant to do so. Under general covenants to repair, the lessee is liable to damages for dilapidations to buildings erected,

* The Laws relating to Contracts by Professor Donaldson, and W. C. Glen, Barrister-at-Law. Published by Crosby Lockwood & Co.

during his tenancy, by him or otherwise, as well as to the buildings forming part of the estate when the lease was granted, and the whole must be given up in a state of substantial repair; but he is not bound to make good defects in the buildings from lapse of time, so long as the buildings are not rendered unfit for occupation by such defects; he would, however, be bound to repair any accident accruing from such defects of lapse of time as it would be considered the result of neglecting what he ought to have attended to. At the same time that the law is stringent on the subject of repairs of dilapidations under a general covenant to repair, it is not unjust, for the courts will take into consideration any evidence *with regard to general condition*, to show ruin and decay from age and infirmity in the buildings at the time the lessee entered into occupation, and return a verdict for amount of damages accordingly; and hence the necessity of a careful survey of the premises at such time by duly authorized parties, and a carefully drawn specification of the state of the premises, for the law will not require of a tenant to give a new house for an old one. Without a covenant to "alter and improve," a lessee will not be allowed material and expensive alterations of buildings, externally or interiorly,—not even though by so doing he may have doubled their value,—but with such covenant, on the contrary, he is bound to alterations and improvements as well as to substantial repairs.

It appears that there is a considerable difference between a covenant to keep in repair, and a covenant to leave buildings in repair; inasmuch as in the former case he is liable for breach of contract, immediately he suffers them to decay, though reasonable time will be allowed for doing so; in the second case, of a covenant to leave in repair, an act for breach of contract will not lie until the expiration of the term, even though the buildings he pulled down during the tenancy.

A lessee should never engage to sustain and repair ruinous buildings, for if any part be so far gone as to require pulling down and rebuilding, the law will not consider such rebuilding as the performance of his covenant to sustain and repair.

A promise, by word of mouth, from lessor or lessee, to repair, is held as valid as a covenant under a seal.

An "injunction" may be obtained by a landlord to restrain a tenant from any act of determined mischief, if applied for immediately on evidence of the intent, and may even be obtained by any person having even only contingent interests in the property.

If a lessee, under a covenant to keep in repair, suffer the premises to fall into a state of dilapidation, a notice must be served by the landlord, who will then have a right at any time before repairs to bring an action of ejectment against the lessee.

On a lessor becoming acquainted with any necessity for repairs, of which the lessee has covenanted the performance, he should serve on the lessee a notice specifying the same, evidence of which, on any action afterwards brought by the lessor for dilapidations, will materially affect the lessee's defence.

TABLE FOR THE FOURTH AND FIFTH POWER OF NUMBERS.

Number.	4th Power	5th Power	Number.	4th Power.	5th Power.
1	1	1	41	2825761	115856201
2	16	32	42	3111696	130691232
3	81	243	43	3418801	147008443
4	256	1024	44	3748096	164916224
5	625	3125	45	4100625	184528125
6	1296	7776	46	4477456	205962976
7	2401	16807	47	4879681	229345007
8	4096	32768	48	5308416	254803968
9	6561	59049	49	5764081	282475249
10	10000	100000	50	6250000	312500000
11	14641	161051	51	6765201	345025251
12	20736	248832	52	7311616	380204032
13	28561	371293	53	7890481	418195493
14	38416	537824	54	8503056	459165024
15	50625	759375	55	9150625	503284375
16	65536	1048576	56	9834496	550731776
17	83521	1419857	57	10556001	601692057
18	104976	1889568	58	11316496	656356768
19	130321	2476099	59	12117361	714924299
20	160000	3200000	60	12960000	777600000
21	194481	4084101	61	13845841	844596301
22	234256	5153632	62	14776336	916132832
23	279841	6436343	63	15752961	992436543
24	331776	7962624	64	16777216	1073741824
25	390625	9765625	65	17850625	1160290625
26	456976	11881376	66	18974736	1252332576
27	531441	14348907	67	20151121	1350125107
28	614656	17210368	68	21381376	1453933568
29	707281	20511149	69	22667121	1564031349
30	810000	24300000	70	24010000	1680700000
31	923521	28629151	71	25411681	1804229351
32	1048576	33554432	72	26873856	1934917632
33	1185921	39135393	73	28398241	2073071593
34	1336336	45435424	74	29986576	2219006624
35	1500625	52521875	75	31640625	2373046875
36	1679616	60466176	76	33362176	2535525376
37	1874161	69343957	77	35153041	2706784157
38	2085136	79235168	78	37015056	2887174368
39	2313441	90224199	79	38950081	3077056399
40	2560000	102400000	80	40960000	3276800000

WEIGHT OF MATERIALS.

	Ton.	Cwt.
64 feet cube Fir	1	0
39 " " Oak	1	0
60 " " Elm	1	0
45 " " Ash	1	0
15 " " Portland Stone	1	0
13 " " Marble	1	0
20 " " Chalk	1	0
55 feet superficial Purbeck Paving	1	0
70 " " York Paving	1	0
24 feet cube Sand	1	0
18 " " Earth	1	0
17 " " Clay	1	0
36 " " Water	1	0
450 Stock Bricks	1	0
1000 Stock Bricks	2	4
1 rod Brickwork	13	0
100 Plain Tiles	1	1
1000 Pan Tiles	2	2
100 foot Paving Tiles	0	11
100 10-inch Paving Tiles	0	7½

ROOF COVERING.

Slate.

1 ton of Westmoreland Slates will cover	2 squares.
1 ton of Welsh Rag	1½ to 2 ditto.
1000 Duchess Slates	9 ditto.
1000 Countess Slates	5 ditto.
1000 Ladies Slates	3½ ditto.
1000 Tavistock Slates	2½ ditto.

A square of Westmoreland or Welsh Rag Slating will weigh 10 cwt.
A square of Duchess, Countess or Ladies Slating will weigh 6 cwt.

	Ft.	In.		Ft.	In.
Welsh Slates called Doubles, average	1	1	by	0	6
" Ladies	1	3	"	0	8
" Countesses	1	8	"	0	10
" Duchesses	2	0	"	1	0
" Rags	3	0	"	2	0
" Queens	3	0	"	2	0
" Imperials	2	6	"	2	0
" Patent	2	6	"	2	0

Tiling.

768 plain Tiles, 6 inch guage	1 square
655 plain Tiles, 7 inch guage	1 ditto.

276 plain Tiles, 8 inch guage	1 square.		
180 pan Tiles, 10 inch guage	1 ditto.		
	lbs.	oz.	
A plain Tile is 10½ inches long, 6¼ wide, ⅝ inch thick; weighs	2	5	
A pan Tile is 13½ inches long, 9½ inches wide, ½ inch thick; weighs...	4	11	
	Cwt.	qr.	lb.
1 square of pan Tiling will weigh..	7	2	0
1 ditto plain Tiling	14	2	0
1 ditto Countess or Ladies Slating	6	0	0
1 ditto Welsh Rag or Westmoreland ditto	10	0	0
1 ditto Lead, 7lbs. to the foot	6	1	0
1 ditto Copper, 16 oz. or 1lb. to the foot	0	3	16
I ditto Zinc, cast 1-16th of an inch thick	2	0	6
1 ditto Zinc, cast 1-32nd of an inch thick	1	0	4

Laths.

500 feet run, any length, is 1 bundle plain tile.
30 bundles 1 load.
120 feet run, 1 bundle of pan tile laths.
1 bundle of each will do 1 square of tiling.

Lime.

25 striked bushels or 100 pecks, 1 hundred of Lime.
46,656 cube inches, 1 cube yard, or 27 cube feet containing 21⅘ bushels.
31¼ feet cube, 1 hundred of Lime.
1½ hundred of Chalk Lime and three loads of Sand to 1 rod of Brickwork.
1 hundred Stone of Lime and 3½ yards Sand to 1 rod of Brickwork.
2 bushels of Lime to 1 square ef plain Tiling.
36 bushels of Cement, and 36 bushels of sharp Sand to 1 rod of reduced Brickwork.

Mortar.

27 cube feet, or 22 striked bushels, 1 load of Mortar.
½ hundred of Lime, with a proportionate quantity of Sand, will make 1 load of Mortar.
1134 cube inches, or 8 duodecimal inches, 1 hod of Mortar; a hod of Mortar being 9 inches by 9 inches, and 14 inches long.
2 hods of Mortar to a bushel nearly.
1728 cube inches, 1 foot.
1 foot 3 inches cube, 1 bushel.
4 hods of Mortar will lay 100 Bricks.
180 hods, or 96 bushels, 1 rod.

Sand.

18 heaped bushels, or 22 striked bushels, or 1 cube yard, 1 single load of Sand.
36 heaped bushels, or 44 striked bushels, or 2 yards cube, 1 double load of Sand.
3 single loads of Sand to 1 rod of Brickwork, with Chalk Lime.
3½ single loads of Sand to 1 rod of Brickwork, with Stone Lime.

1 bushel of Sand to 1 square plain Tiling.
1 striked bushel is to one heaped as 4 is to 5.

Brickwork.

272 feet superficial, 1 rod of Brickwork, at 1½ brick or 13½ inches thick, which is considered the standard thickness, and to which all brickwork is reduced.

306 cube feet, 1 rod of reduced Brickwork, being the cube quantity produced by multiplying 272 feet by 13½ inches (or 1½ brick the standard thickness of all brickwork.)

4500 Bricks (allowing for waste), will build 1 rod of reduced Brickwork.

16½ Bricks to each reduced foot of Brickwork.

8 Bricks to 1 foot superficial of Marl, facing laid Flemish bond.

10 Bricks to 1 foot superficial guaged arches.

To reduce cube feet of Brickwork to the standard thickness of 1½ brick, multiply by 8 and divide by 9, the standard thickness of 1½ Brick, 13½ inches being 9-8th of a foot.

A Stock Brick is 8¾ inches long, 4¼ inches wide, and 2½ inches thick; each brick weighs about 4lbs. 15 oz.

384 Bricks to 1 cube yard.

Brickwork per Foot Superficial in various Thicknesses.

Note.—In the following Table, to make the amounts without fractions approximate to the number of 4,500 bricks to the rod, add to every One Thousand Bricks in the Table four and one-half Bricks. As Example,—take the number at 9,000 feet, the number of Bricks will be found in the Table under two and one-half Brickwork to be 247,500; add four and one-half Bricks to each Thousand, and two Bricks for the remaining hundreds. Example—

$$247 \times 4\tfrac{1}{2} = 1,111 \times 2 = 1,113 \times 247,500 = 248,613.$$

Now in the Table of reduced quantities, 9,000 feet of two-and-half reduced Brickwork, gives 55 rods and 40 feet. Multiply 4,500 Bricks in one rod by 55. Thus :—55 × 4,500 = 247,500 × 1,100, the number of bricks in 40 feet of Two-and-half Brickwork (see Table) will be = 248,600, which result will be found to come within 13 Bricks in a ¼ of a million.

A TABLE

Showing the value of Masonry and Brickwork in cube yards, and rods reduced from ¼d. per foot to 5s. per foot cube.

	Per Cube Foot.		Cube Yard.			Reduced Rod.		
	s.	*d.*	£	*s.*	*d.*	£	*s.*	*d.*
At	0	0¼	0	0	6¾	0	6	4½
	0	0½	0	1	1½	0	12	9
	0	0¾	0	1	8¼	0	19	1½
	0	1	0	2	3	1	5	6
	0	2	0	4	6	2	11	0¾
	0	3	0	6	9	2	16	6
	0	4	0	9	0	5	2	0
	0	5	0	11	3	6	7	6
	0	6	0	13	6	7	13	0
	0	7	0	15	9	8	18	6
	0	8	0	18	0	10	4	0
	0	9	1	0	3	11	9	6
	0	10	1	2	6	12	15	0
	0	11	1	4	9	14	0	6
	1	0	1	7	0	15	6	0
	1	1	1	9	3	16	11	6
	1	2	1	11	6	17	17	0
	1	3	1	13	9	19	2	6
	1	4	1	16	0	20	8	0
	1	5	1	18	3	21	13	6
	1	6	2	0	6	22	19	0
	1	7	2	2	9	24	4	6
	1	8	2	5	0	25	10	0
	1	9	2	7	3	26	15	6
	1	10	2	9	6	28	1	0
	1	11	2	11	9	29	6	6
	2	0	2	14	0	30	12	0
	2	6	3	7	6	38	5	0
	3	0	4	1	0	45	18	0
	3	6	4	14	6	53	11	0
	4	0	5	8	0	61	4	0
	4	6	6	1	6	68	17	0
	5	0	6	15	0	76	10	0

NOTE.—A rod of Brickwork contains $11\frac{9}{27}$ cube yards or 306 cube feet.

RULE.—To find the number of bricks required to form any curve or arch measure the length of the curve of the Soffit of the arch in feet and inches one half of which multiplied by 36 will give the number of bricks required for one yard lineal of 4½ in. brickwork.

A TABLE

Showing the number of cube yards of earth in 1 yard lineal in Wells, &c.

Diameter. Ft.	In.	Cube. Yds.	Ft.
2	6	0	15
3	0	0	21.3
3	6	1	2
4	0	1	11
4	6	1	21
5	0	2	5
5	6	2	17
6	0	3	4
6	6	3	19
7	0	4	8
7	6	5	0
8	0	5	15

Wells.

Diameter. Ft.	In.		Gals. in 1 ft. in depth.
3	0	clear of Brickwork	43
3	6	"	59
4	0	"	77
4	6	"	98
5	0	"	120
5	6	"	146
6	0	"	173
6	6	"	203
7	0	"	235
7	6	"	270
8	0	"	308
8	6	"	348
9	0	"	390
9	6	"	435
10	0	"	480

A TABLE

Showing the number of Tiles required to drain 1 acre of land at different widths.

Yds.		12 in. Tiles.	15 in. Tiles.		12 in. Tiles.	15 in. Tiles.
4	Rows distant or apart on surface.	3630	2904	If laid at an angle of 45° for Cuttings and Embankments, &c. the number will be.	5704	4356
5		2904	2323		3260	3484
6		2420	1936		3030	2904
7		2074	1659		3137	2488
8		1815	1452		2732	2178
9		1613	1291		2420	1936
10		1452	1162		2178	1743
11		1320	1056		1980	1584
12		1210	968		1815	145

A TABLE.

Giving the approximate number of Bricks required to construct any Walls or Buildings, per superficial foot, from half-brick work to 2½ bricks in thickness—4500 bricks being the quantity necessary for one rod of Reduced Brickwork, allowing for waste.

Superficial Ft.	Half Brick.	One Brick.	One and half Brick.	Two Bricks.	Two and half Bricks.
1	5½	11	16½	22	27½
2	11	22	33	44	55
3	16½	33	49½	66	82½
4	22	44	66	88	110
5	27½	55	82½	110	137½
6	33	66	99	132	165
7	38½	77	115½	154	192½
8	44	88	132	176	220
9	49½	99	148½	198	247½
10	55	110	165	220	275
20	110	220	330	440	550
30	165	330	495	660	825
40	220	440	660	880	1,100
50	275	555	825	1,100	1,375
60	330	666	990	1,320	1,650
70	385	770	1,155	1,540	1,925
80	440	880	1,320	1,760	2,200
90	495	990	1,485	1,980	2,475
100	550	1,100	1,650	2,200	2,750
200	1,100	2,200	3,300	4,400	5,500
300	1,650	3,300	4 950	6,600	8,250
400	2,200	4,400	6,600	8,800	11,000
500	2,750	5.500	8,250	11,000	13,750
600	3,300	6,600	9,900	13,200	16,500
700	3,850	7,700	11,550	15,400	19,250
800	4,400	8,800	13,200	17,600	22,000
900	4,950	9,900	14,850	19,800	24,750
1000	5,500	11.000	16,500	22,000	27,500
2,000	11,000	22,000	33,000	44,000	55,000
3,000	16,500	33,000	49,500	66,000	82,500
4,000	22,000	44,000	66,000	88,000	110,000
5.000	27,500	55,000	82,500	110.000	137,500
6,000	33,000	66,000	99.000	132,000	165,000
7,000	38,500	77,000	115,500	154,000	192,500
8,000	44,000	88.000	132,000	176,000	220,000
9,000	49,500	99.000	148,500	198,000	247,500
10,000	55,000	110,000	165,000	220,000	275,000
11,000	60,500	121,000	181,500	242,000	302,500
12,000	66,000	132,000	198.000	264,000	330,000
13.000	71,500	143,000	214,500	286,000	357,500
14,000	77,000	154.000	231,000	308,000	385,000
15,000	82,500	165.000	247,500	330,000	412,500
16,000	88,000	176.000	264.000	352,000	440,000
17,000	93,500	187,000	280,500	374,000	467,500
18,000	99,000	198 000	297.000	396,000	495,000
19,000	104,500	209,000	313.500	418,000	522,500
20,000	110,000	220.000	330,000	440,000	550,000

A TABLE.

Showing the quantity of Reduced Brickwork, at various thicknesses, in any given number of superficial feet.

Area of Wall	Half Brick.				One Brick.				One and Half Brick.				Two Bricks.				Two and Half Bricks.			
In Feet.	rod.	qrs.	ft.	in.	rod.	qrs.	ft.	in.	rod.	qrs.	ft.	in.	rod.	qrs.	ft.	in.	rod.	qrs.	in.	ft.
1				4				8			1	0			1	4			1	8
2				8			1	4			2	0			2	8			3	4
3			1	0			2	0			3	0			4	0			5	0
4			1	4			2	8			4	0			5	4			6	8
5			1	8			3	4			5	0			6	8			8	4
6			2	0			4	0			6	0			8	0			10	0
7			2	4			4	8			7	0			9	4			11	8
8			2	8			5	4			8	0			10	8			13	4
9			3	0			6	0			9	0			12	0			15	0
10			3	4			6	8			10	0			13	4			16	8
20			6	8			13	4			20	0			26	8			33	4
30			10	0			20	0			30	0			40	0			50	0
40			13	4			26	8			40	0			53	4			66	8
50			16	8			33	4			50	0			66	8		1	15	4
60			20	0			40	0			60	0		1	12	0		1	32	0
70			23	4			46	8		1	2	0		1	25	4		1	48	8
80			26	8			53	4		1	12	0		1	38	8		1	65	4
90			30	0			60	0		1	22	0		1	52	0		2	14	0
100			33	4			66	8		1	32	0		1	65	4		2	30	8
200			66	8		1	65	4		2	64	0		3	62	8	1	0	61	4
300		1	32	0		2	64	0	1	0	28	0	1	1	60	0	1	3	24	0
400		1	65	4		3	62	8	1	1	60	0	1	3	57	4	2	1	54	8
500		2	30	8	1	0	61	4	1	3	24	0	2	1	54	8	3	0	17	4
600		2	64	0	1	1	60	0	2	0	56	0	2	3	52	0	3	2	48	0
700		3	29	4	1	2	58	8	2	2	20	0	3	1	49	4	4	1	10	8
800		3	62	8	1	3	57	4	2	3	52	0	3	3	46	8	4	3	41	4
900	1	0	28	0	2	0	56	0	3	1	16	0	4	1	44	0	5	2	4	0
1000	1	0	61	4	2	1	54	8	3	2	48	0	4	3	41	4	6	0	34	8
2,000	2	1	54	8	4	3	41	4	7	1	28	0	9	3	14	8	12	1	1	4
3,000	3	2	48	0	7	1	28	0	11	0	8	0	14	2	56	0	18	1	36	0
4,000	4	3	41	4	9	3	14	8	14	2	56	0	19	2	29	4	24	2	2	8
5,000	6	0	34	8	12	1	1	4	18	1	36	0	24	2	2	8	30	2	37	4
6,000	7	1	28	0	14	2	56	0	22	0	16	0	29	1	44	0	36	3	4	0
7,000	8	2	21	4	17	0	42	8	25	2	64	0	34	1	17	4	42	3	38	8
8,000	9	3	14	8	19	2	29	4	29	1	44	0	39	0	58	8	49	0	5	4
9,000	11	0	8	0	22	0	16	0	33	0	24	0	44	0	32	0	55	0	40	0
10,000	12	1	1	4	24	2	2	8	36	3	4	0	49	0	5	4	61	1	6	8
11,000	13	1	62	8	26	3	57	4	40	1	52	0	53	3	46	8	67	1	41	4
12,000	14	2	56	0	29	1	44	0	44	0	32	0	58	3	20	0	73	2	8	0
13,000	15	3	49	4	31	3	30	8	47	3	12	0	63	2	61	4	79	2	42	8
14,000	17	0	42	8	34	1	17	4	51	1	60	0	68	2	34	8	85	3	9	4
15,000	18	1	36	0	36	3	4	0	55	0	40	0	73	2	8	0	91	3	64	0
16,000	19	2	29	4	39	0	58	8	58	3	20	0	78	1	49	4	98	0	50	8
17,000	20	3	22	8	41	2	45	4	62	2	0	0	83	1	22	8	104	1	37	4
18,000	22	0	16	0	44	0	32	0	66	0	48	0	88	0	64	0	110	2	24	0
19,000	23	1	9	4	46	2	18	8	69	3	28	0	93	0	37	4	116	3	10	8
20,000	24	2	2	8	49	0	5	4	73	2	8	0	98	0	10	8	122	3	65	4

A TABLE

Showing the weight of 1 foot of Square bar iron, from ½ inch square to 3½ inches square.

Weight per Cubic Foot, 475 lbs. / Weight per Cubic Foot, 495 lbs.

Light Hammered.				Close Hammered.			
Side of Square.		Weight.		Side of Square.		Weight.	
In.	Eighths.	lbs.	oz.	In.	Eighths.	lbs.	oz.
0	4	0	13	0	4	0	13
0	5	1	4	0	5	1	5½
0	6	1	13	0	6	1	15
0	7	2	8	0	7	2	10
1	0	3	5	1	0	3	7
1	1	4	3	1	1	4	5½
1	2	5	3	1	2	5	6
1	3	6	4	1	3	6	8¼
1	4	7	7	1	4	7	11¾
1	5	8	12	1	5	9	1
1	6	10	2	1	6	10	8½
1	7	11	9	1	7	12	1½
2	0	13	4	2	0	13	12
2	1	14	15	2	1	15	8
2	2	16	12	2	2	17	6
2	3	18	10	2	3	19	6
2	4	20	10	2	4	21	7¼
2	5	22	12	2	5	23	10
2	6	24	15	2	6	26	0¾
2	7	27	4	2	7	28	8½
3	0	29	11	3	0	30	15
3	1	32	4	3	1	33	9
3	2	34	14	3	2	36	4
3	3	37	10	3	3	39	5½
3	4	40	8	3	4	42	2

A TABLE

Showing the weight of 1 foot of Round bar or bolt iron, from ⅛ of an inch to 6 inches diameter.

In.	lbs.	oz.	In.	lbs.	oz.
0⅛	0	2	2	11	0
0¼	0	3½	2⅛	12	0
0⅜	0	7½	2¼	13	7
0½	0	11½	2⅜	15	0
0⅝	1	1	2½	16	0¾
0¾	1	8	2⅝	18	5
0⅞	2	2	2¾	20	2
1	2	13	2⅞	22	0
1⅛	3	8	3	24	0
1¼	4	4	3¼	28	0
1⅜	5	0	3½	32	8
1½	6	0	3¾	37	0
1⅝	7	0	4	43	0
1¾	8	2	5	70	0
1⅞	9	8	6	97	0

TABLE OF THE WEIGHT OF A LINEAL FOOT OF CAST IRON PIPES IN LBS.

Diameter of Bore in inches.	Thickness of the Metal in inches.					
	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	one inch.
2	11.4	15.2	19.0			
2½	13.3	17.7	22.1	26.5		
3	15.3	20.4	25.5	30.5	35.5	40.5
3½	17.1	22.8	28.5	34.2	39.9	45.6
4	19.2	25.6	31.9	38.2	44.5	50.8
4½	21.0	28.0	35.0	41.9	48.8	55.7
5	22.9	30.5	38.1	45.7	53.3	60.9
5½	24.9	33.2	41.4	49.6	59.8	66.0
6	26.7	35.6	44.5	53.3	62.1	70.9
6½	28.6	38.1	47.6	57.1	66.6	76.1
7	30.5	40.6	50.7	60.8	70.9	81.0
7½	32.5	43.3	54.1	64.9	75.7	86.5
8	34.3	45.7	57.1	68.5	79.9	91.3
8½	36.3	48.4	60.5	72.5	84.5	96.8
9	38.3	50.9	63.6	76.3	89.0	101.7
9½	40.0	53.3	66.6	79.9	93.2	106.5
10	...	56.0	70.0	83.9	97.8	111.7
10½	...	58.5	73.1	87.7	102.3	116.9
11	...	62.3	77.8	93.4	106.6	121.8
11½	...	63.6	79.4	95.2	110.0	127.0
12	...	...	82.6	99.1	115.6	132.1
13	...	...	89.0	106.8	124.6	142.2
14	...	...	95.5	114.6	133.6	152.6
15	...	...	...	122.1	142.1	162.6
16	...	...	...	130.8	152.6	173.0
17	...	...	...	137.6	160.2	183.0
18	...	...	...	...	169.9	193.1

NOTE.—Socket rims or flanges must be added to this weight one foot for each socket and one foot for two flanges is usual.

RULE.—Find the Circumference in inches, adding one inch to the bore multiply by 12 for one foot lineal at one inch thick, multiply the produce by 27, cut off two figures to the right, the remainder is lbs.; in one foot on inch thick, deduct $\frac{1}{8}$ $\frac{1}{7}$ $\frac{1}{6}$ $\frac{1}{5}$ $\frac{1}{4}$ for the lesser thickness; or, in any other thickness, find the number of cubic inches in one foot lineal; multiply by 27; cutt off two figures to the right, the remainder will be lbs. in one foot.

A TABLE

Giving the weight a round Column of Cast Iron will bear securely at different Lengths, beginning at 6 ft.

Height of Column.

Weight to be Supported.

Diameter	6 ft.		8 ft.		10 ft.		12 ft.		14 ft.		16 ft.		18 ft.		20 ft.		22 ft.		24 ft.	
inches.	ton	cwt.	ton	cwt.	ton	cwt.	ton	cwt.	ton	cwt.	ton	cwt.	ton	cwt.	ton	cwt.	ton	cwt.	ton	cwt.
2½	5	5	4	15	4	5	3	15	3	5	2	15	2	5	1	15	1	5	4	15
3	8	0	7	7	6	14	6	1	5	8	4	15	4	2	3	9	2	16	2	3
3½	11	5	10	5	9	5	8	5	7	5	6	5	5	5	4	5	3	5	2	5
4	15	0	13	19	12	18	11	17	10	16	9	15	8	14	7	13	6	12	5	11
4½	19	5	18	4	17	3	16	2	15	1	14	0	12	19	11	18	10	17	9	16
5	24	0	22	15	21	10	20	5	19	0	17	15	16	10	15	5	14	0	12	15
6	35	0	33	15	32	10	31	5	30	0	28	15	27	10	26	5	25	0	23	15
7	48	0	46	15	45	10	43	5	42	0	40	15	39	10	38	5	37	0	35	15
8	63	0	61	0	59	0	57	0	55	0	53	0	51	0	49	0	47	0	45	0
9	80	0	78	0	76	0	74	0	72	0	70	0	68	0	66	0	64	4	62	0
10	99	0	97	0	95	0	93	0	91	0	89	0	87	0	85	0	83	0	81	0
11	120	0	118	0	116	0	114	0	112	0	110	0	108	0	106	0	104	0	102	0
12	143	0	141	0	139	0	137	0	135	0	133	0	131	0	129	0	127	0	125	0

RULE.—Square the diameter, and the number of superficial inches, less one, is the safe sustaining weight in tons at six feet high, less proportionally every two feet, as per table.

A TABLE

Showing the Weight of Metal Plate per Square Foot.

	Wrought Iron.	Cast Iron.	Cast Copper.	Cast Brass.	Cast Lead.	Cast Zinc.
.6th of an In.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1	2.5	2.3	2.9	2.7	3.7	2.3
2	5.1	4 7	5.7	5.5	7.4	4.7
3	7.6	7.0	8.6	8.2	11.1	7.0
4	10.1	9.4	11 4	11.0	14.8	9.4
5	12 7	11.7	14.3	13.7	18.5	11 7
6	15.2	14.0	17.2	16 4	22.2	14.0
7	17.9	16.4	20.0	19.2	25.9	16.4
8	20.3	18 8	22.9	21.9	29.5	18.7
9	22.8	21.1	25.7	24 6	33.2	21.4
10	25.4	23.5	28.6	27.4	36.9	23.1

NOTE.—This Table is calculated in lbs. and decimal parts of a lb.

Cast Iron Rain Water Pipes per yard.

2 in.	2½ in.	3 in.	3½ in.	4 in.
1*s.* 1*d.*	2*s.* 3*d.*	2*s.* 6*d.*	3*s.* 3*d.*	3*s.* 9*d.* per yard lineal

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Cast Iron Eave Gutters, per yard lineal.

3 in.	3½ in.	4 in.	4½ in.	5 in.	6 in.
10*d.*	1*s.*	1*s.* 2*d.*	1*s.* 3*d.*	1*s.* 6*d.*	1*s.* 9*d*

Hopper Heads for Pipes.

2 in	2½ in.	3 in.	3½ in.	4 in.
2*s.*	2*s.* 3*d.*	2*s.* 6*d.*	3*s.* 3*d.*	3*s.* 9*d.*

Shoes for Ditto.

1*s.*	1*s.* 3*d.*	1*s.* 6*d.*	2*s.*	2*s.* 6*d.*

NOTE.—For weight see table of weight of Pipes ; or—Rule, reduce to cubic inch, multiply by 27, cut off two figures to the right of the product, the remainder is lbs.

Rules

To find the weight of any quantities of iron, wrought and close hammered, reduce the quantity into cubic inches, multiply the product by 28, cut off two figures to the right, the remainder is lbs

To find the weight of cast iron, proceed as above, only multiply by 27 instead of 28.

Secondly—

Multiply the number of ⅛ of an inch in the section, and divide by 19, gives the number of lbs. in 1 foot.

Example.—Bar of iron 1¼ in. by ½ in.—1¼ is 10⅛, ½ in. is 4⅛; 10 × 4=40, divide by 19)40(2 lbs. 2 oz. to 1 foot.
38
—
2

Cylinder to Measures.

Square the diameter in inches, cut off one figure to the right, the remainder denotes the number of gallons in 3 feet.

Example.—12 × 12 = 14|4, or 14 gallons 4 pints in 3 feet.
9 × 9 = 8,1, or 8 gallons 1 pint in ditto.

A TABLE

Showing the weight per foot superficial of Lead, from 1/16 of an inch thick to 1 inch thick, Specific Gravity 11,325, Weight per Cube foot 708 lbs.

Thickness. In.		Weight. lbs.	Thickness. In.		Weight. lbs.
1/16	....	3¾	¼	....	14¾
1/12	....	5	⅓	....	19¾
1/10	....	6	½	....	28¾
⅛	....	7½	¾	....	44¼
⅙	....	10	1	....	59
⅕	....	12			

A TABLE

Showing the value of 1 cwt. of Lead from ⅛ of a penny per lb. to 6d.

d.		*£.*	*s.*	*d.*	*d.*		*£.*	*s.*	*d.*
⅛	is	0	1	2	3¼	is	1	10	4
¼	„	0	2	4	3½	„	1	12	8
½	„	0	4	8	3¾	„	1	15	0
¾	„	0	7	0	4	„	1	17	4
1	„	0	9	4	4¼	„	1	19	8
1¼	„	0	11	8	4½	„	2	2	0
1½	„	0	14	0	4¾	„	2	4	4
1¾	„	0	16	4	5	„	2	6	8
2	„	0	18	8	5¼	„	2	9	0
2¼	„	1	1	0	5½	„	2	11	4
2½	„	1	3	4	5¾	„	2	13	8
2¾	„	1	5	8	6	„	2	16	0
3	„	1	8	0					

A TABLE

Showing how many feet superficial a cwt. of Sheet Lead will cover on a flat roof, or gutter, &c. from 4 lbs. to 12 lbs. per foot; the value of each superficial foot or square, according to the several weights—viz., at 3¾*d.* per lb., or £1 15*s.* 0*d.* per cwt. for all under 7 lbs. per foot superficial; and 3½*d.* per lb., or £1 12*s.* 8*d.* per cwt., for 7 lbs. per foot superficial, and all above, including labour, solder, &c.

Weight per foot superficial.		1 cwt. will cover superficial.		Expense per foot superficial.			Expense per square on 100 ft. superficial.		
lbs.		Ft.	In.	£.	s.	d.	£.	s.	d.
4	Milled Lead £1 15*s.* per cwt. or 3¾*d.* per lb.	28	0	0	1	3	6	5	0
5		22	5	0	1	6¾	7	16	3
6		18	8	0	1	10½	9	7	6
7		16	0	0	2	0½	10	4	2
8	Cast Lead £1 12*s.* 8*d.* per cwt. or 3½*d.* per lb.	14	0	0	2	4	11	13	4
9		12	5⅓	0	2	7½	13	2	6
10		11	3	0	2	11	14	11	8
11		10	2	0	3	2½	16	0	10
12		9	4	0	3	6	17	10	0

NOTE—By the above table any quantity of covering may be easily estimated according to the thickness of the Lead.

A TABLE

Showing the weight of Length Pipes per length in lbs.

Bore. In.	Length. Ft.	Common. lbs.	Middling. lbs.	Strong. lbs.
½	15	16	...	...
¾	15	24	27	30
1	15	30	40	43
1¼	12	36	44	53
1½	12	48	56	67
2	10	56	70	83
2½	10	70	89	100

LAND TABLE

	Square yds.	Side of Square. yds.	ft.	in.	pts.	Diameter of a circle. yds.	ft.	in.	pts.
1 acre	4840	69	1	8	6	78	1	6	1
3 roods	3630	60	0	9	0	67	2	11	5
2 roods	2420	47	0	7	0	55	1		4
1 rood	1210	34	2	4	3	39	0		0

Relative Value of British and Foreign Square and Cub. Measure.

Country or Place.	Square Foot in English. Square Inches.	Cubic Foot in English Cubic Inches.
Amsterdam	124·255	1385·070
Berlin	148·693	1813·162
Berne	133·287	1538·798
Dantzic	127·690	1442·897
Dresden...	124·099	1382·463
France	163·558	2091·743
Geneva	369·024	7088·951
Hanover	131·194	1502·696
Leipsic	123·432	1371·329
Lisbon	167·547	2168·728
Prussia	152·670	1886·390
Rhineland	152·670	1886·390
Riga	116·424	1250·215
Rome	137·358	1609·835
Spain	123·882	1378·002
Sweden	136·515	1545·041
Venice	167·142	2560·102
Vienna	155·002	1029·714

Relative Value of British and Foreign Road Measure.

Country or Place.	Name of Measure.	English Yards.	No. of each equal to 100 English mls.
Denmark	Mile	8,244	21,348
Flanders	League	6,864	25,641
France	League of 2,000 Toises	4,263	41,285
Germany	Mile (Long)............	10,126	17,381
Hamburgh ...	Mile	8,244	21,348
Hanover	Mile	11,559	15,226
Holland.........	Mile	8,103	21,725
Hungary	Mile	9,113	19,313
Netherlands ...	Mile Metrical	1,093	161,024
Poland	Mile (Long)............	8,103	21,725
Portugal	League	6,762	26,035
Prusssia.........	Mile	8,237	21,367
Russia	Verst	1,067	150,814
Spain	League Common	7,416	23,732
Sweden	Mile	11,700	15,042
Switzerland ...	Mile	9,153	19,288
Turkey	Berri	1,826	96,385

Relative Value of British and Foreign Weights.

WEIGHTS.

French.	British.
Gramme	15,434 grains.
Decigramme	1·5434 "
Centigramme	0·1543 "
Milligramme	0·0154 "
Decagramme	154·3400 "
Hectogramme	3·2154 oz. troy.
	or 3·5270 oz. avoird.
Kilogramme	2·6795 lb. troy.
	or 2·2048 lb. avoird.
Myriagramme	28·7850 lb. troy.
	or 22·0480 lb. avoird.
Quintal	1 cwt. 3 qrs. 24½ lbs.
Millier or Bar	9 tons 10 cwt. 3 qrs. 12 lbs.

MEASURES OF LENGTH.

French.	British.
Myriametre	6·2138 miles.
Metre	39·3710 inches.
Decimetre	3·0371 "
Centimetre	0·3937 "
Millimetre	0·0393 "
Decametre	32·8090 feet.
Hectometre	328·0900 "
Kilometre	1093·6000 yards.

MEASURES OF SUPERFICES.

French.	British.
Are	110·6000 sqr. yds.
Deciare	11·9600 "
Centiare	10·7840 sqr. feet
Milliare	155·0000 sqr. ins.
Decare	1196·0000 sqr. yds.
Hectare	2·4712 acres.

A Table to find the Areas of Polygons, the length of one side being given.

Trigon	3 Sides...............	0·4350
Pentagon	5 „	1·7203
Hexagon	6 „	2·5981
Heptagon	7 „	3·6339
Octagon	8 „	4·8244
Nonagon	9 „	6·1818
Decagon...............	10 „	7·6942
Undecagon............	11 „	9·3556
Duodecagon	12 „	11·1962

Rule—Multiply the square of the side by the figures in Column 2.

An Easy Ready Reckoner.

1		2		3		4		5		6		7		8		9		10	
0	0¼	0	0½	0	0¾	0	1	0	1¼	0	1½	0	1¾	0	2	0	2¼	0	2½
0	0½	0	1	0	1½	0	2	0	2½	0	3	0	3½	0	4	0	4½	0	5
0	0¾	0	1½	0	2¼	0	3	0	3¾	0	4½	0	5¼	0	6	0	6¾	0	7½
0	1	0	2	0	3	0	4	0	5	0	6	0	7	0	8	0	9	0	10
0	1¼	0	2½	0	3¾	0	5	0	6¼	0	7½	0	8¾	0	10	0	11¼	1	0½
0	1½	0	3	0	4½	0	6	0	7½	0	9	0	10½	1	0	1	1½	1	3
0	1¾	0	3½	0	5¼	0	7	0	8¾	0	10½	1	0¼	1	2	1	3¾	1	5½
0	2	0	4	0	6	0	8	0	10	1	0	1	2	1	4	1	6	1	8
0	2¼	0	4½	0	6¾	0	9	0	11¼	1	1½	1	3¾	1	6	1	8¼	1	10½
0	2½	0	5	0	7½	0	10	1	0½	1	3	1	5½	1	8	1	10½	2	1
0	2¾	0	5½	0	8¼	0	11	1	1¾	1	4½	1	7¼	1	10	2	0¾	2	3½
0	3	0	6	0	9	1	0	1	3	1	6	1	9	2	0	2	3	2	6
0	3¼	0	6½	0	9¾	1	1	1	4¼	1	7½	1	10¾	2	2	2	5¼	2	8½
0	3½	0	7	0	10½	1	2	1	5½	1	9	2	0½	2	4	2	7½	2	11
0	3¾	0	7½	0	11¼	1	3	1	6¾	1	10½	2	2¼	2	6	2	9¾	3	11½
0	4	0	8	1	0	1	4	1	8	2	0	2	4	2	8	3	0	3	4
0	4¼	0	8½	1	0¾	1	5	1	9¼	2	1½	2	5¾	2	10	3	2¼	3	6½
0	4½	0	9	1	1½	1	6	1	10½	2	3	2	7½	3	0	3	4½	3	9
0	4¾	0	9½	1	2¼	1	7	1	11¾	2	4½	2	9¼	3	2	3	6¾	3	1½
0	5	0	10	1	3	1	8	2	1	2	6	2	11	3	4	3	9	4	2
0	5¼	0	10½	1	3¾	1	9	2	2¼	2	7½	3	0¾	3	6	3	11¼	4	4½
0	5½	0	11	1	4½	1	10	2	3½	2	9	3	2½	3	8	4	1½	4	7
0	5¾	0	11½	1	5¼	1	11	2	4¾	2	10½	3	4¼	3	10	4	3¾	4	9½
0	6	1	0	1	6	2	0	2	6	3	0	3	6	4	0	4	6	5	0
0	6¼	1	0½	1	6¾	2	1	2	7¼	3	1½	3	7¾	4	2	4	8¼	5	2½
0	6½	1	1	1	7½	2	2	2	8½	3	3	3	9½	4	4	4	10½	5	5
0	6¾	1	1½	1	8¼	2	3	2	9¾	3	4½	3	11¼	4	6	5	0¾	5	7½
0	7	1	2	1	9	2	4	2	11	3	6	4	1	4	8	5	3	5	10
0	7¼	1	2½	1	9¾	2	5	3	0¼	3	7½	4	2¾	4	10	5	5¼	6	0½
0	7½	1	3	1	10½	2	6	3	1½	3	9	4	4½	5	0	5	7½	6	3
0	7¾	1	3½	1	11¼	2	7	3	2¾	3	10½	4	6¼	5	2	5	9¾	6	5½
0	8	1	4	2	0	2	8	3	4	4	0	4	8	5	4	6	0	6	8
0	8¼	1	4½	2	0¾	2	9	3	5¼	4	1½	4	9¾	5	6	6	2¼	6	10½
0	8½	1	5	2	1½	2	10	3	6½	4	3	4	11½	5	8	6	4½	7	1
0	8¾	1	5½	2	2¼	2	11	3	7¾	4	4½	5	1¼	5	10	6	6¾	7	3½
0	9	1	6	2	3	3	0	3	9	4	6	5	3	6	0	6	9	7	6
0	9¼	1	6½	2	3¾	3	1	3	10¼	4	7½	5	4¾	6	2	6	11¼	7	8½
0	9½	1	7	2	4½	3	2	3	11½	4	9	5	6½	6	4	7	1½	7	11
0	9¾	1	7½	2	5¼	3	3	4	0¾	4	10½	5	8¼	6	6	7	3¾	8	1
0	10	1	8	2	6	3	4	4	2	5	0	5	10	6	8	7	6	8	4½
0	10¼	1	8½	2	6¾	3	5	4	3¼	5	1½	5	11¾	6	10	7	8¼	8	6
0	10½	1	9	2	7½	3	6	4	4½	5	3	6	1½	7	0	7	10½	8	9½
0	10¾	1	9½	2	8¼	3	7	4	5¾	5	4½	6	3¼	7	2	8	0¾	8	11
0	11	1	10	2	9	3	8	4	7	5	6	6	5	7	4	8	3	9	2½
0	11¼	1	10½	2	9¾	3	9	4	8¼	5	7½	6	6¾	7	6	8	5¼	9	4

An Easy Ready Reckoner—*Continued.*

1		2		3		4		5		6		7		8		9		10	
0	11½	1	11	2	10½	3	10	4	9½	5	9	6	8½	7	8	8	7½	9	7
0	11¾	1	11½	2	11¼	3	11	4	10¾	5	10½	6	10¼	7	10	8	9¾	9	9½
1	0	2	0	3	0	4	0	5	0	6	0	7	0	8	0	9	0	10	0
1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	10	10
1	2	2	4	3	6	4	8	5	10	7	0	8	2	9	4	10	6	11	8
1	3	2	6	3	9	5	0	6	3	7	6	8	9	10	0	11	3	12	6
1	4	2	8	4	0	5	4	6	8	8	0	9	4	10	8	12	0	13	4
1	5	2	10	4	3	5	8	7	1	8	6	9	11	11	4	12	9	14	2
1	6	3	0	4	6	6	0	7	6	9	0	10	6	12	0	13	6	15	0
1	7	3	2	4	9	6	4	7	11	9	6	11	1	12	8	14	3	15	10
1	8	3	4	5	0	6	8	8	4	10	0	11	8	13	4	15	0	16	8
1	9	3	6	5	3	7	0	8	9	10	6	12	3	14	0	15	9	17	6
1	10	3	8	5	6	7	4	9	2	11	0	12	10	14	8	16	6	18	4
1	11	3	10	5	9	7	8	9	7	11	6	13	5	15	4	17	3	19	2

Table for Wages, &c.

Year.	Per Month.			Per Week.			Per Day.			Year.	Per Month.			Per Week.			Per Day.		
£	£	s.	d.	£	s.	d.	£	s.	d.	£	£	s.	d	£	s.	d.	£	s.	d.
1	0	1	8	0	0	4¾	0	0	0¾	15	1	5	0	0	5	9	0	0	10
2	0	3	4	0	0	9¼	0	0	1¼	16	1	6	8	0	6	1¾	0	0	10½
3	0	5	0	0	1	1¾	0	0	2¾	17	1	8	4	0	6	6¼	0	0	11¼
4	0	6	8	0	1	6¼	0	0	2	18	1	10	0	0	6	10¾	0	0	11¾
5	0	8	4	0	1	11	0	0	3¼	19	1	11	8	0	7	3¾	0	1	0½
6	0	10	0	0	2	3½	0	0	4	20	1	13	4	0	7	8	0	1	1¼
7	0	11	8	0	2	8¼	0	0	4½	30	2	10	0	0	11	6	0	1	7¾
8	0	13	4	0	3	0¾	0	0	5¼	40	3	6	8	0	15	4½	0	2	2¼
9	0	15	0	0	3	5½	0	0	6	50	4	3	4	0	19	2	0	2	9
10	0	16	8	0	3	10	0	0	6½	60	5	0	0	1	3	0¼	0	3	3¼
11	0	18	4	0	4	2¾	0	0	7¼	70	5	16	8	1	6	10¼	0	3	10
12	1	0	0	0	4	7¼	0	0	8	80	6	13	4	1	10	6¼	0	4	4½
13	1	1	8	0	4	11¾	0	0	8½	90	7	10	0	1	14	9¼	0	4	11½
14	1	3	4	0	5	4¼	0	0	9¼	100	8	6	8	1	18	4½	0	5	5¾

Discount Table.

2½ per cent.... is	0	6	per £1		12½ per cent.... is	2	6	per £1
3 " .... "	0	7¼	"		15 " .... "	3	0	"
4 " .... "	0	9¾	"		17½ " .... "	3	6	"
5 " .... "	1	0	"		20 " .... "	4	0	"
6 " .... "	1	2	"		22½ " .... "	4	6	"
6½ " .... "	1	6	"		25 " .... "	5	0	"
10 " .... "	2	0	"		30 " .... "	[illegible]	0	"

An Interest Ready Reckoner.

For any Amount, at 2, 2½, 3, 3½, 4, 4½, and 5 per cent., for any number of Days.

Products.	3 per cent.			3½ per cent.			4 per cent.			4½ per cent.			5 per cent.		
	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
100	0	0	2	0	0	2½	0	0	2½	0	0	3	0	0	3¼
200	0	0	4	0	0	4½	0	0	5¼	0	0	6	0	0	6½
300	0	0	6	0	0	7	0	0	8	0	0	8	0	0	9¾
400	0	0	8	0	0	9¼	0	0	10½	0	0	11¾	0	1	1¼
500	0	0	9¾	0	0	11½	0	1	1¼	0	1	2¾	0	1	4½
600	0	0	11¾	0	1	1¾	0	1	3¾	0	1	5¾	0	1	7¾
700	0	1	1¾	0	1	4	0	1	6½	0	1	8¾	0	1	11
800	0	1	3¾	0	1	6½	0	1	9	0	1	11¾	0	2	2¼
900	0	1	5¾	0	1	8¾	0	1	11¾	0	2	2¾	0	2	5½
1,000	0	1	7¾	0	1	11	0	2	2¼	0	2	5½	0	2	9
2,000	0	3	3½	0	3	10	0	4	4½	0	4	11¼	0	5	5¾
3,000	0	4	11¼	0	5	9	0	6	7	0	7	4¾	0	8	2¾
4,000	0	6	7	0	7	8	0	8	9¼	0	9	10¼	0	10	11½
5,000	0	8	2½	0	9	7	0	10	11½	0	12	4	0	13	8¼
6,000	0	9	10¼	0	11	6	0	13	1¾	0	14	9½	0	16	5¼
7,000	0	11	6	0	13	5	0	15	4	0	17	3	0	19	2
8,000	0	13	1¾	0	15	4	0	17	6½	0	19	8¾	1	1	11
9,000	0	14	9½	0	17	3	0	19	8¾	1	2	2¼	1	4	7¾
10,000	0	16	5¼	0	19	2	1	1	11	1	4	8	1	7	4¾
20,000	1	12	10½	1	18	4¼	2	3	10	2	9	3¾	2	14	9½
30,000	2	9	3¾	2	17	6½	3	5	9	3	13	11¾	4	2	2¼
40,000	3	5	9	3	16	8½	4	7	8	4	18	7½	5	9	7
50,000	4	2	2¼	4	15	10¾	5	9	7	6	3	3½	6	16	11¾
60,000	4	18	7½	5	15	0¾	6	11	6	7	7	11¼	8	4	4½
70,000	5	15	0¾	6	14	3	7	13	5	8	12	7¼	9	11	9¼
80,000	6	11	6	7	13	5	8	15	4	9	17	3	10	19	2
90,000	7	7	11¼	8	12	7¼	9	17	3	11	11	1	12	6	7
100,000	8	4	4½	9	11	9¼	10	19	2	12	6	7	13	13	11½
200,000	16	8	9¼	19	3	6¾	21	18	4¼	24	13	1¾	27	7	11¼
300,000	24	13	1¾	28	15	4	32	17	6½	36	19	8¾	41	1	11
400,000	32	17	6½	38	7	1½	43	16	8½	49	6	3½	54	15	10¾
500,000	41	1	11	47	18	10¾	54	15	10¾	61	12	10½	68	9	10¼
600,000	49	6	3½	57	10	8¼	65	15	0¾	73	19	5½	82	3	10
700,000	57	10	8¼	67	2	5½	76	14	3	86	6	0¼	95	17	9¾
800,000	65	15	0¾	76	14	3	87	13	5	98	12	7¼	109	11	9¼
900,000	73	19	5½	86	6	0¼	98	12	7¼	110	19	2	123	5	9
1000,000	82	3	10	95	17	9¼	109	11	9	123	5	9	136	19	8¾

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